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ERRATA

Pp. 80–85, in Tables IX–XV, in headings: "Phytoplankton in millions per 50 m. haul with N 50 V net", *for* "50 m." *read* "100 m."

Pp. 89 and 105, under heading "Siphonophora" *for* "Leres and Van Riemsdigk" *read* "Lens and Van Riemsdijk".

P. 270, in Table LI, in heading, *for* "page 268" *read* "page 272".

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THE PLANKTON OF THE SOUTH GEORGIA WHALING GROUNDS AND ADJACENT WATERS, 1926–1927

BY

A. C. HARDY, M.A.,
Professor of Zoology and Oceanography, University College, Hull,

AND

E. R. GUNTHER, M.A.

Part I. Introduction, Hydrology and Methods (A. C. H. and E. R. G.).
Part II. The Phytoplankton (A. C. H.).
Part III. The Zooplankton, Section I (E. R. G. and A. C. H.).
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THE PLANKTON OF THE SOUTH GEORGIA WHALING GROUNDS AND ADJACENT WATERS, 1926–1927

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PART I. INTRODUCTION, HYDROLOGY AND METHODS

By A. C. Hardy, M.A. and E. R. Gunther, M.A.

GENERAL INTRODUCTION

THE Blue, Fin, Sei and Humpback whales (*Balaenoptera musculus*, *B. physalus*, *B. borealis* and *Megaptera nodosa*) with which the Discovery Investigations are primarily concerned are well known to be plankton feeders. They come in the southern summer to feed in the Antarctic waters, which are rich in food; and at the approach of winter return to the warmer and lower latitudes for breeding. A knowledge of the plankton of these southern regions is therefore important in an attempt to understand the natural history of these whales.

It has been shown by Mackintosh and Wheeler (1929) that the food of at least the Blue and the Fin whales caught at South Georgia consists almost entirely of one species of Euphausiacea: *Euphausia superba*.

Whilst particular attention must be paid to the study of *Euphausia superba*, it is also desirable to investigate the main features of the whole plankton community of which it forms a part. It is important to study the production of the phytoplankton upon which these Euphausians in turn depend for food. It is likewise important to study the more abundant zooplankton forms which may be either competitors with the Euphausians or actually enemies preying upon them. The Hyperiid amphipod, *Parathemisto gaudichaudi*, has been found at times to swarm in vast numbers in this region, feeding largely upon young Euphausians. The varying conditions found in the plankton community, particularly in the quantities of phytoplankton produced, must if possible be correlated with the changes in the physical and chemical environment as determined by the hydrologists.

From another point of view, a knowledge of the planktonic changes in time and space throughout the area of investigation is of value, in that it may afford supplementary evidence to that of the physical and chemical observations in the recognition of the main different water masses and their movement. Such knowledge will also be of importance in understanding the migrations of the whales.

Comparable plankton samples have been collected over a wide area of the Southern Ocean by means of standard closing vertical and horizontal tow-nets of fine, medium and coarse mesh, and hydrological samples and observations have also been taken. In addition, more detailed surveys have been made by these methods in the whaling areas of South Georgia and the South Shetlands.

The present report deals with collections made during the years 1926–7 in the region of South Georgia and some of the adjacent areas. Still more extensive surveys have been made in the following years and are still being carried out; so that it should be borne in mind that some of the conclusions reached in this paper may be modified by the results of work now in progress: particularly will this be so in regard to seasonal distribution, where conclusions are based upon somewhat inadequate grounds. This account, however, may be of interest since it presents for the first time the results of an intensive study of a plankton community in the Antarctic Zone.[1] It is based upon the analysis of over one thousand samples (1071). Its aim is to offer as a starting-point an account of the plankton with which the results of work in later seasons and other localities may be compared and in general to form an introduction to the ecology of the Antarctic seas. A consideration of the relationship between the distribution of the whales and that of the plankton, and between the zooplankton and the phytoplankton, has led to the recognition of certain general principles of pelagic ecology. It also affords material for a discussion on the validity of some recognized planktological methods. An indication is obtained of the remarkable patchiness in distribution of many of the plankton animals.

The work was planned and carried out under the direction of our leader, Dr Stanley Kemp, F.R.S., in the ships, R.R.S. 'Discovery' and R.R.S. 'William Scoresby', during their first commissions. The authors, together at various times with Mr J. E. Hamilton, Dr J. F. G. Wheeler, Mr D. Dilwyn John and Mr F. C. Fraser, had the pleasure of carrying out the work in the field under Dr Kemp's leadership. We are most grateful for the extensive assistance we received from Dr Helène Bargmann, who analysed the samples from the "100 cm." horizontal nets (N 100 H), and from the late Mr Andrew Scott, of Liverpool University, who examined all the Copepoda and analysed the samples from the "70 cm." horizontal nets (N 70 H) for Copepoda; we are ourselves responsible for the analyses of the samples from the other nets as follows: A. C. H. for the "50 cm." vertical nets (N 50 V); E. R. G. for the "70 cm." vertical nets (N 70 V).

The following specialists have kindly assisted in the identification of different groups of organisms, and to them we tender our grateful thanks:

Dr H. Bargmann—Chaetognatha
Dr K. H. Barnard—Amphipoda
Mr E. T. Browne—Medusae
Mr A. Earland—Foraminifera
Mr G. P. Farran—Copepoda
Mr F. C. Fraser—Ostracoda
Mr E. Heron-Allen—Foraminifera
Miss A. L. Massy—Pteropoda
Mr C. C. A. Monro—Polychaeta
Mr Andrew Scott—Copepoda
Captain A. K. Totton—Siphonophora

---

[1] Geographically South Georgia is well to the north of the Antarctic Circle, but hydrologically it lies well within the Antarctic Zone.

The late Mr Andrew Scott, at the time of his death, was engaged on a systematic account of the Copepoda; but it is to be feared that the work is too incomplete for publication.

We have had extensive help from the Statistical Branch of the Ministry of Agriculture and Fisheries, who have carried out numerous calculations for us from the results of our analyses. To Mr T. Edser, head of this Department, and his staff we tender our grateful thanks for much helpful advice and for all the trouble they have taken with the work.

Finally, we are greatly indebted to the Trustees of the British Museum, who have allowed us to work in the laboratories of the British Museum (Natural History), and to the officers and staff of that institution for their never-failing kindness and ready help. Part of the work was also carried out in the Department of Zoology and Oceanography in the University College of Hull.

GEOGRAPHY AND HYDROLOGY OF SOUTH GEORGIA AND ADJACENT AREAS

The island of South Georgia lies upon a submarine ridge, which stretches in a parabolic curve, from the end of South America to meet the Antarctic Continent at the western extremity of Graham Land. This ridge, which is almost continuous throughout its length, has been called the Scotia Arc.[1] On it also lie the Burdwood Bank, the Shag Rocks, the South Sandwich Islands and the South Orkneys. To the west it encloses a deep oceanic area, connected with the Pacific Ocean by Drake Passage, and now known as the Scotia Sea. To the east stretches the great Southern Ocean, where, at a little distance beyond the ridge, depths of over 8000 m. have recently been obtained by the 'Meteor' and the 'Discovery II'. To the north of the Arc is the Atlantic Ocean and to the south lies the Weddell Sea. The chart in Fig. 1 shows the contours of the sea floor in this area.

South Georgia itself, a narrow mountainous island, 116 miles long and roughly 20 miles wide, lies between the parallels 54° and 55° S and between the meridians 36° and 38° W. Its long axis runs from north-west to south-east, and the coast along its north-east side and at its two ends is deeply indented by long fjords, which form admirable shelter for the whaling stations and ships. The lofty mountains, which form a chain running the length of the island, rise steeply out of the sea from a submerged plateau or shelf which surrounds the island at a depth of 150 to some 250 m. on all sides. In most directions this shelf extends for some 30 or 40 miles, but to the north-west—towards the Shag Rocks—it extends for some 80 miles. When the edge of the plateau is reached, the sea bottom falls away very steeply to the ocean floor. The chart in Fig. 2 shows the contours of the sea floor immediately round South Georgia, and Fig. 3 shows a diagrammatic section passing through the island at right angles to its axis and along the line *AB* in Fig. 2.

[1] It has also, at Suess's suggestion, been called the South Antillean Arc.

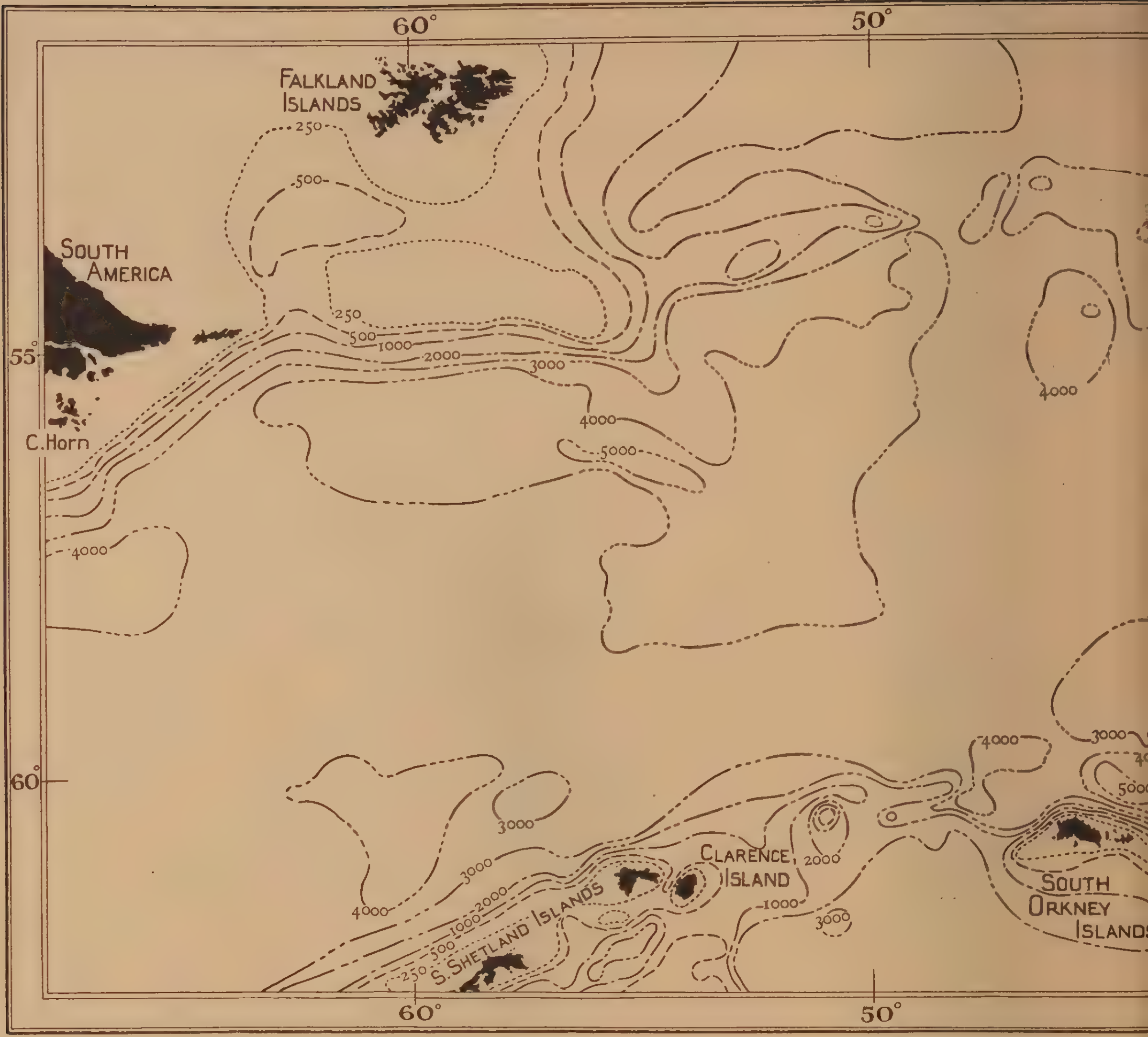
60°
50°
FALKLAND ISLANDS
SOUTH AMERICA
55°
C.Horn
250
500
1000
2000
3000
4000
5000
60°
CLARENCE ISLAND
S. SHETLAND ISLANDS
SOUTH ORKNEY
60°
50°

Fig. 1. Contour chart of the ocean floor showing the position of South Georgia on the Scotia Arc,

For a full discussion of the hydrological conditions round South Georgia and of the South Atlantic generally, reference should be made to the hydrological reports by Mr H. F. P. Herdman, Mr A. J. Clowes and Mr G. E. R. Deacon, which will be published soon after the present paper. But since a knowledge of the hydrological conditions is essential to the understanding of the plankton distribution, the authors have kindly placed at our disposal provisional sections of their forthcoming paper from which the following information is abstracted together with direct quotations.[1]

The South Atlantic Ocean may be divided into four zones, each with well-marked characters: the Antarctic, the sub-Antarctic, the sub-Tropical and the Tropical Zones.

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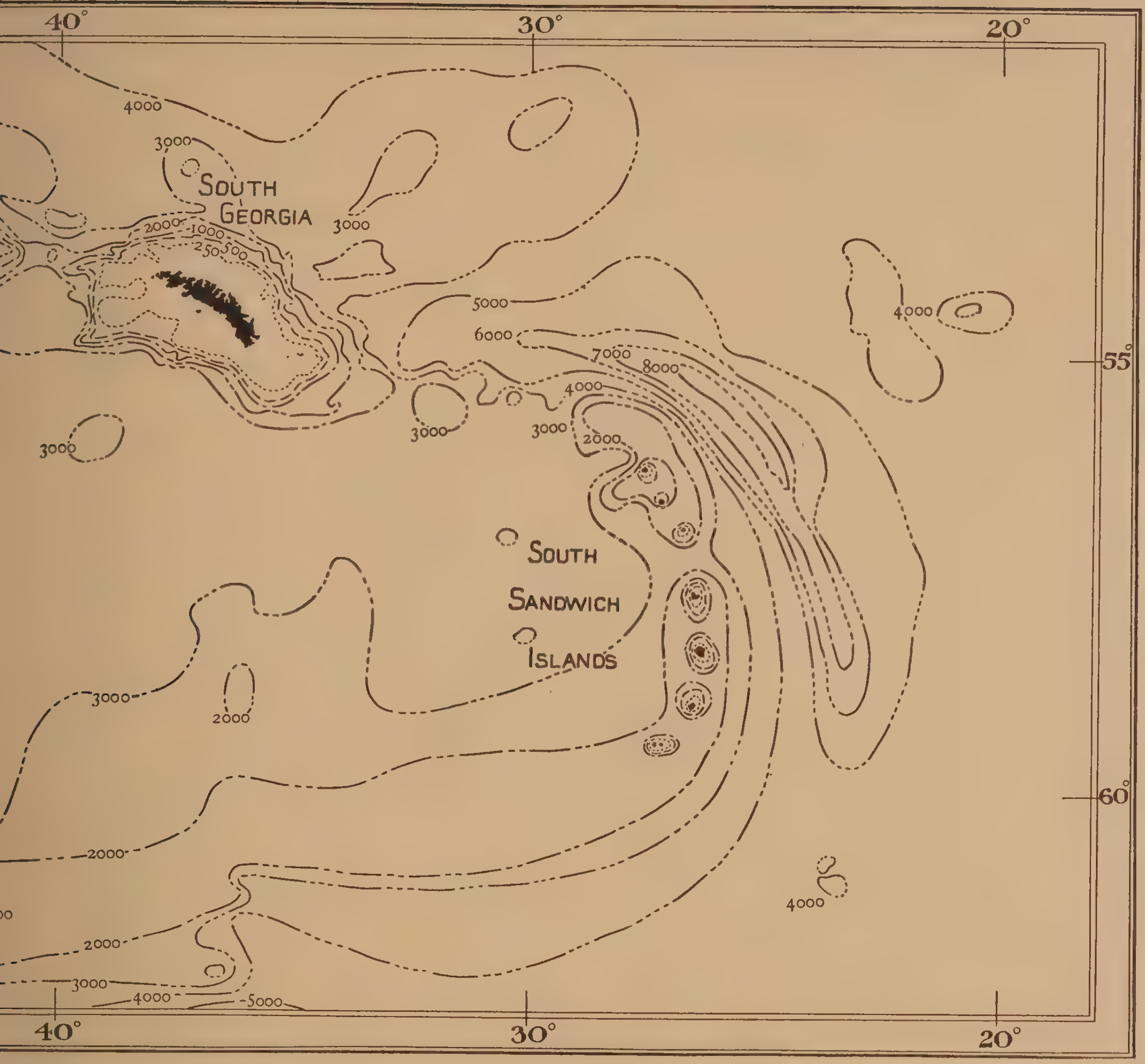
[1] Since this section of the report was written Deacon (1933) has published a general account of the hydrology of the South Atlantic Ocean.


40°
30°
20°
4000
3000
South Georgia
2000
1000
250
500
3000
5000
6000
7000
8000
4000
3000
2000
3000
3000
55°
South Sandwich Islands
3000
2000
4000
60°
2000
2000
3000
4000
5000
40°
30°
20°

pon soundings taken during the Discovery Investigations (after Herdman, 1932).

In the present paper we are concerned only with the Antarctic and sub-Antarctic Zones, South Georgia lying some 250 miles within the former. "The surface layer of the Antarctic Zone is composed of cold poorly saline water, which owes its low temperature and salinity to the additions of fresh water which it has received from melting ice. This cold water moves slowly northwards until it meets the surface water of the sub-Antarctic Zone, which is more saline but warmer and lighter. The Antarctic water therefore sinks below it. The line along which the cold Antarctic water sinks below the warmer sub-Antarctic water forms the northern boundary of the Antarctic region." This line is called the "Antarctic Convergence". "The depth to which the Antarctic surface water extends increases very slowly from south to north and reaches approximately 250 m., before it meets the sub-Antarctic water.

"The sub-Antarctic Zone is in the region of constant westerly winds and the surface water is moving eastwards with the West Wind Drift. This water is in continuous movement round the southern ocean. The zone includes Cape Horn, the Falkland Islands and that part of the Patagonian coast under the influence of the Falkland current. It also just includes Gough Island and Tristan da Cunha."

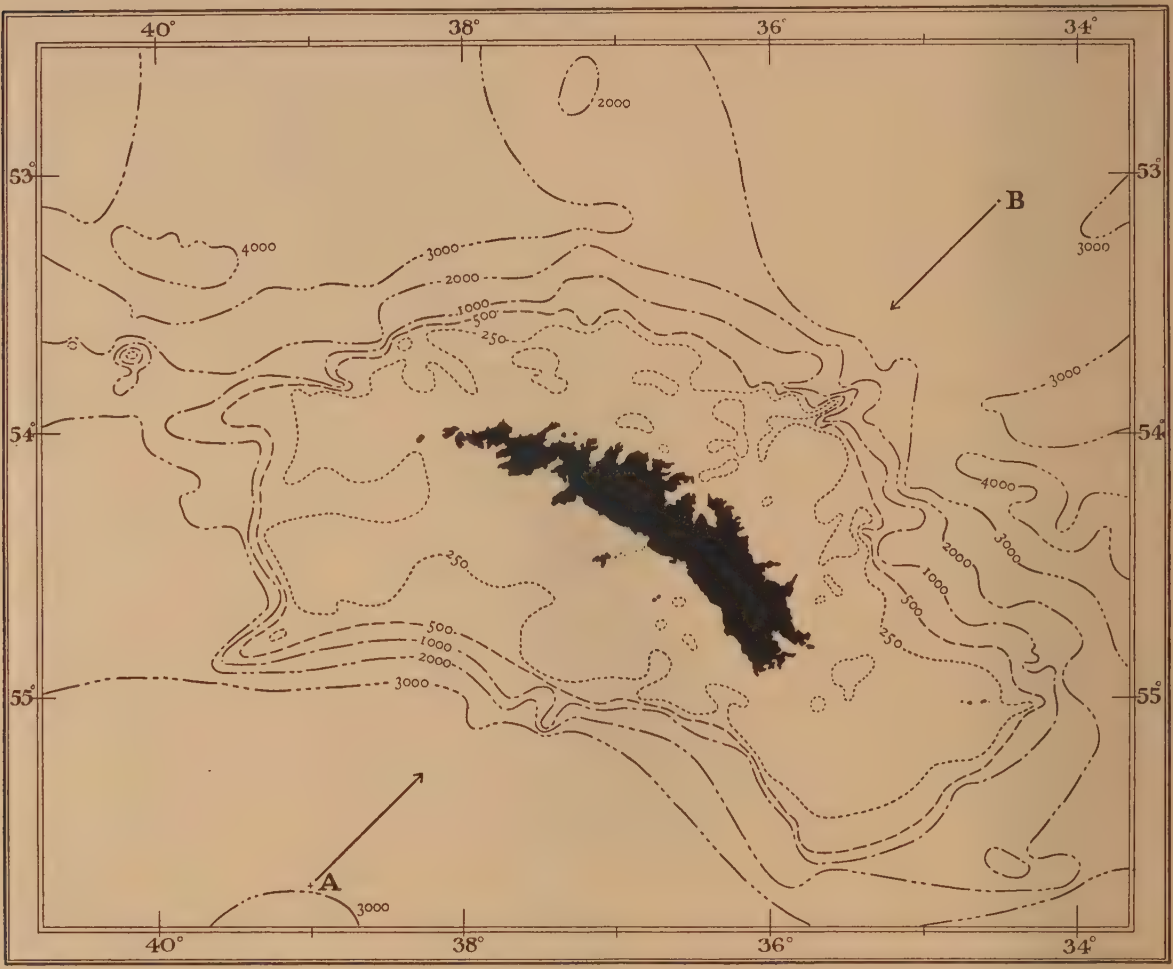


Fig. 2. Contour chart showing the submarine plateau upon which South Georgia stands and covering the main area of the 1926–7 plankton survey (after Herdman, 1932).

For the general distribution of these zones in the region under discussion see Fig. 4.

"In the Antarctic region three distinct layers of water can be observed in the vertical section. In the upper layer is the cold and poorly saline Antarctic water, below which the salinity and temperature increase to a maximum in an intermediate layer; while deeper still, towards the bottom, the temperature, and also slightly the salinity, decrease as a third layer is encountered.

"The work of Dr O. Pettersson and J. W. Sandström has shown how polar influences give rise to a circulation of water in the ocean and a system of layers such as has been described in the previous paragraph. The melting of ice by the heat of the sun, or by warmer water, produces fresh water, and this will give rise to an accumulation of cold poorly saline water at the surface near the ice. As this light water collects, so it will stream away from the ice at the surface until it meets water of lower density under which

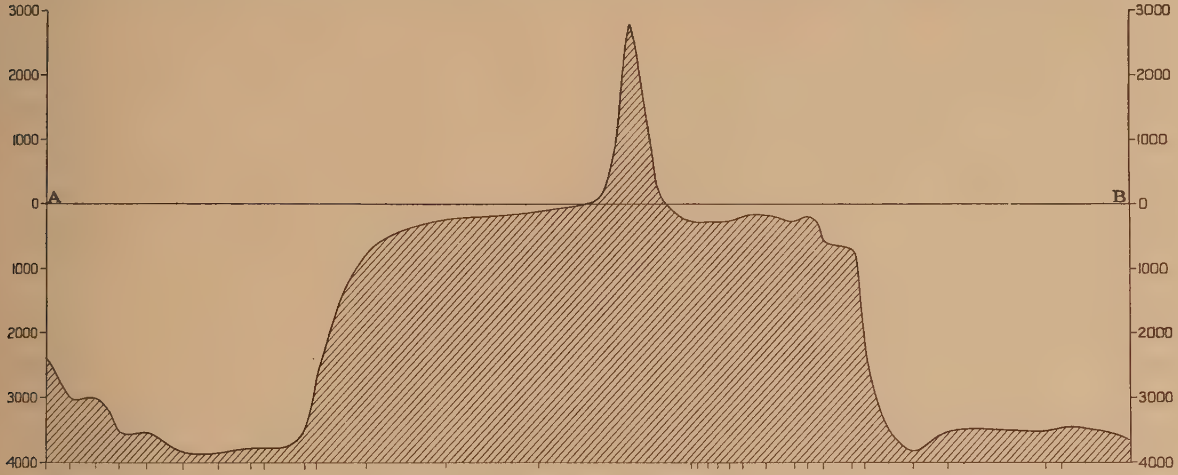


Fig. 3. Section through South Georgia along the line *AB* in Fig. 2 with vertical scale exaggerated. Heights and depths in metres. The positions of soundings are indicated along the base line.

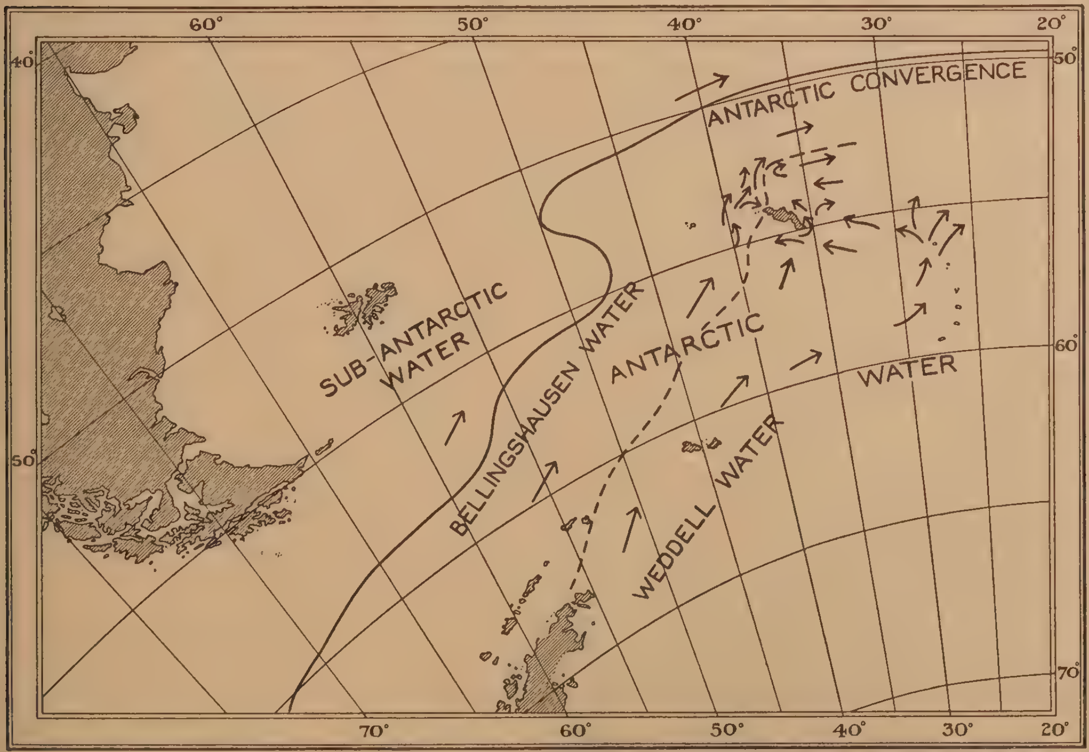

60°
50°
40°
30°
20°
40°
50°
60°
70°
ANTARCTIC CONVERGENCE
SUB-ANTARCTIC WATER
BELLINGSHAUSEN WATER
ANTARCTIC WATER
WEDDELL WATER
50°
70°
60°
50°
40°
30°
20°

Fig. 4. Chart showing the line of the Antarctic Convergence, separating the Antarctic and the sub-Antarctic Zones, and the course of the two surface currents which influence South Georgia within the Antarctic Zone.

it will sink. It is in this way that the Antarctic surface layer is formed. The movements in the Antarctic surface water in winter have been found to be very small indeed and increase to a maximum in summer when most ice is melting; the salinity of this water is for the same reason greatest in winter and least in summer. Then there is water which has been cooled by contact with ice, *but has only been very slightly diluted.* It is dense; and it therefore sinks, forming the cold Antarctic bottom water which fills the depths of the deep polar basins and streams slowly northwards along the bottom. To compensate for the removal of water from the Antarctic regions in the form of surface and bottom water, there is a flow of warmer water towards the pole in the intermediate layer. This is the part played by the water of the warm intermediate layer which is said by Wüst to have its origin in the surface of the North Atlantic Ocean.[1] It is in this intermediate water that the maximum salinity, temperature, phosphate content and minimum oxygen content are found, and the continual upwelling of the water from this richer layer inside the Antarctic region replenishes the salinity and phosphate content of the Antarctic water."

Fig. 5 shows temperature and salinity curves at two deep-water stations in the Antarctic Zone, one to the south-west and one to the north-east of South Georgia; the different character of the three layers is clearly shown in each (the water immediately against the surface is warmed by summer sunshine and atmospheric conditions).

South Georgia itself is influenced by two currents within the Antarctic Zone, one slightly colder, and more saline, than the other. The colder and more saline current flows out of the north-west corner of the Weddell Sea, and following the curve of the Scotia Arc flows up the north-east side of South Georgia. The slightly warmer current flows from the Bellingshausen Sea through Drake Passage and approaches the south west side of South Georgia. The general course of these currents is shown in Fig. 4.

The actual details of the water movements immediately around South Georgia must vary from year to year, with slight variations in the strength and direction of these two main currents, and with the varying influence of winds. In the present report we are concerned with the actual state of the water movement at the time of our main survey in December–January, 1926–7, and we are greatly indebted to Mr A. J. Clowes, who has worked these movements out in as complete detail as possible by means of dynamic calculations. He has supplied us with the chart of surface movements which we reproduce in Fig. 6. The Weddell Sea water having been curved round by the Scotia Arc is seen approaching South Georgia from the east and south-east. It flows over the continental shelf and up the north-east side of the island; some of it also flows round the south of the island, to the west where it mixes with water from the Bellingshausen Sea, over the wide continental shelf to the westward of the island. We see the Bellingshausen Sea water approaching South Georgia from the south-west, and upon meeting the continental shelf being deflected to the north-west. Apparently it swirls round to the north, for we meet Bellingshausen Sea water again in a strong stream, flowing in towards the north of the island from the north-west. Part of this stream flows over the continental shelf to the west forming an area of mixture with the Weddell Sea water, which has come round from the south-east. After mixing with both Weddell Sea water

---

[1] Clowes (1933) has recently suggested with the aid of charts of dynamic topography and temperature-salinity diagrams that *south* of 46° S the warm and more saline intermediate layer is composed of water of Pacific origin which has entered the region via the Drake Passage.

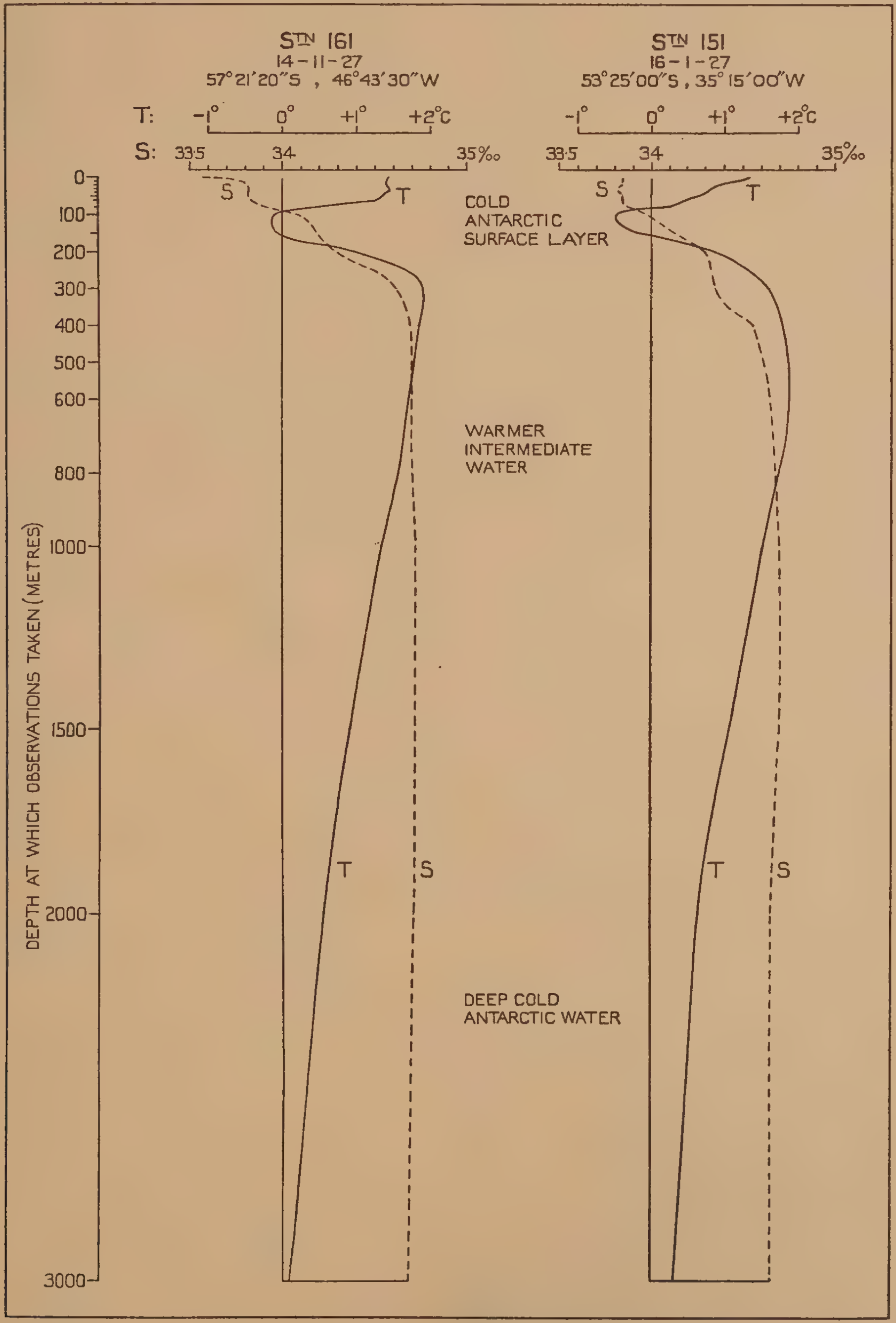
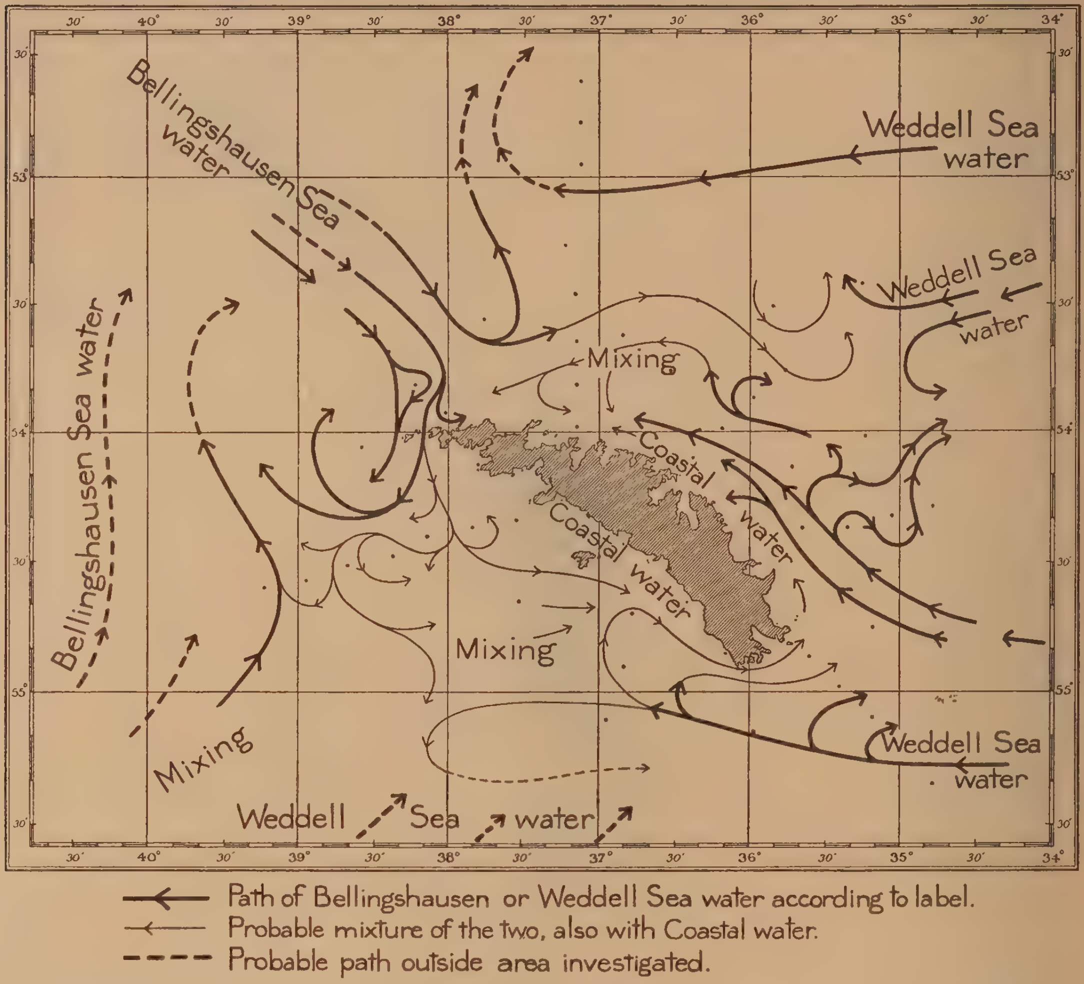


Fig. 5. Temperature and salinity-depth curves at two stations within the Antarctic Zone, one to the south-west and one to the north-east of South Georgia.

and drainage from the land it continues as a current down the south-west coast and round its southern end inside the purer Weddell Sea water, to pass up close against the north-east coast again inside the main Weddell current. The Bellingshausen Sea water and a mixture of it can be distinguished from the Weddell Sea water by its slightly higher temperature and lesser salinity. The other part of the Bellingshausen Sea water approaching from the north-west forms a second area of mixture with the Weddell Sea water off the north-east coast. Beyond all this local disturbance and mixing over the continental shelf the two currents apparently continue their flow to the north-east to be bent round to the east under the influence of the west wind drift. Some Weddell Sea water may also approach South Georgia from the south-west, as shown in the dotted arrows in the figure. Figs. 4 and 6 should be compared with the contour maps in Figs. 1 and 2. The whaling grounds of South Georgia are situated over the submarine plateau on which South Georgia stands, and which sets up this complex system of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30'
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30'
38°
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37°
30'
36°
30'
35°
30'
34°
53°
54°
55°
Bellingshausen Sea water
Weddell Sea water
Weddell Sea water
Mixing
Bellingshausen Sea water
Coastal water
Coastal water
Mixing
Mixing
Weddell Sea water
Weddell Sea water
Path of Bellingshausen or Weddell Sea water according to label.
Probable mixture of the two, also with Coastal water.
Probable path outside area investigated.

Fig. 6. Chart of the surface-water movements round South Georgia in December–January 1926–7 prepared by Mr A. J. Clowes by means of dynamic calculations.

mixture in the path of the two currents. This mixing of waters may have a profound influence upon the plankton production, and so upon the distribution of the whales in the area; a discussion of this will be reserved for a later section.

Figs. 7 and 8 show the vertical distribution of the temperature, salinity and oxygen content of the upper 500 m. of water round South Georgia during the December–January survey, 1926–7. The cold, poorly saline, Antarctic surface layer is clearly shown, and below it the warmer, more saline, intermediate layer. The difference in character between the Bellingshausen Sea water and the Weddell Sea water we have said is very slight; how slight it is will be seen by comparing the "A" line and outside end station of the "G" line, which are Bellingshausen water, with the outside station of the "C", "D" and "E" lines, which are Weddell Sea water. The Bellingshausen Sea water is slightly warmer at the *immediate surface* than the Weddell Sea water. The warm area of mixture of the two currents to the west of the island on the "G" line and round the south of the island is clearly seen and is shown again in the temperature map in Fig. 41 on p. 82. Figs. 9 and 10 show the vertical distribution of the temperature and salinity (and oxygen content at one station only) at the deep-water stations on the oceanic lines between South Georgia and the Falkland Islands in February 1927, and between South Georgia and Tristan da Cunha in February 1926. For the positions of these stations see the maps in Figs. 14 and 11. They each show clearly the differences in hydrological conditions in the Antarctic and the sub-Antarctic Zones on each side of the line of Antarctic Convergence.

Further reference will be made to this information put at our disposal when we are discussing the relation of the plankton to these hydrological conditions in the later sections of the paper. The details of temperature, salinity, oxygen and phosphate distribution and water movements will then be considered. In the present section we are giving a brief outline of the geography of the region under consideration. We are dealing with the plankton from three distinct surface masses of water. There is the sub-Antarctic water to the north which we sampled at a few stations between Tristan da Cunha and South Georgia, and between South Georgia and the Falkland Islands, and there are the two water masses lying within the Antarctic Zone, one on each side of South Georgia. We have also sampled the plankton from the warmer intermediate layer, and occasionally at very deep stations penetrated into the cold bottom layer.

Lastly, in this brief sketch of the geography of the area we must not omit reference to the strong and frequent gales. Whilst over the whole area under consideration the prevailing winds are from the south-west, it appeared to us that South Georgia itself, with its high range of snow-covered mountains, was the centre of many local disturbances of great violence. These frequent storms might be thought to churn up the water to such an extent that the vertical distribution of the plankton in the shallow regions over the continental shelf would be seriously affected; evidence is presented on p. 268 to show that this is not so.

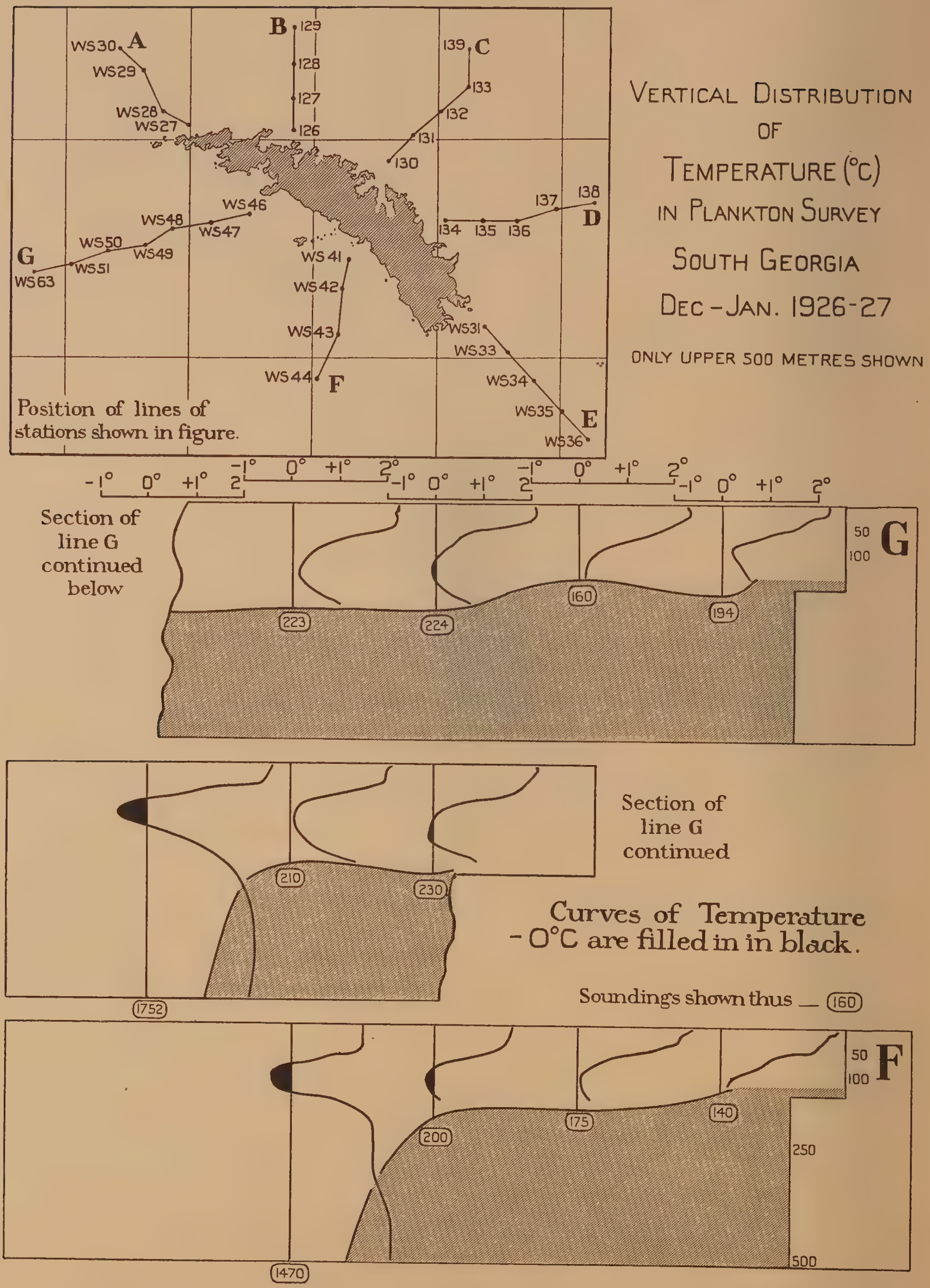

VERTICAL DISTRIBUTION
OF
TEMPERATURE (°C)
IN PLANKTON SURVEY
SOUTH GEORGIA
DEC-JAN. 1926-27
ONLY UPPER 500 METRES SHOWN
A
B
C
D
E
F
G
WS30
WS29
WS28
WS27
129
128
127
126
139
133
132
131
130
134
135
136
137
138
WS46
WS48
WS47
WS50
WS49
WS51
WS63
WS41
WS42
WS43
WS44
WS31
WS33
WS34
WS35
WS36
Position of lines of stations shown in figure.
-1° 0° +1° 2°
Section of line G continued below
50
100
223
224
160
194
Section of line G continued
210
230
1752
Curves of Temperature -0°C are filled in in black.
Soundings shown thus — 160
200
175
140
250
500
1470

Fig. 7.

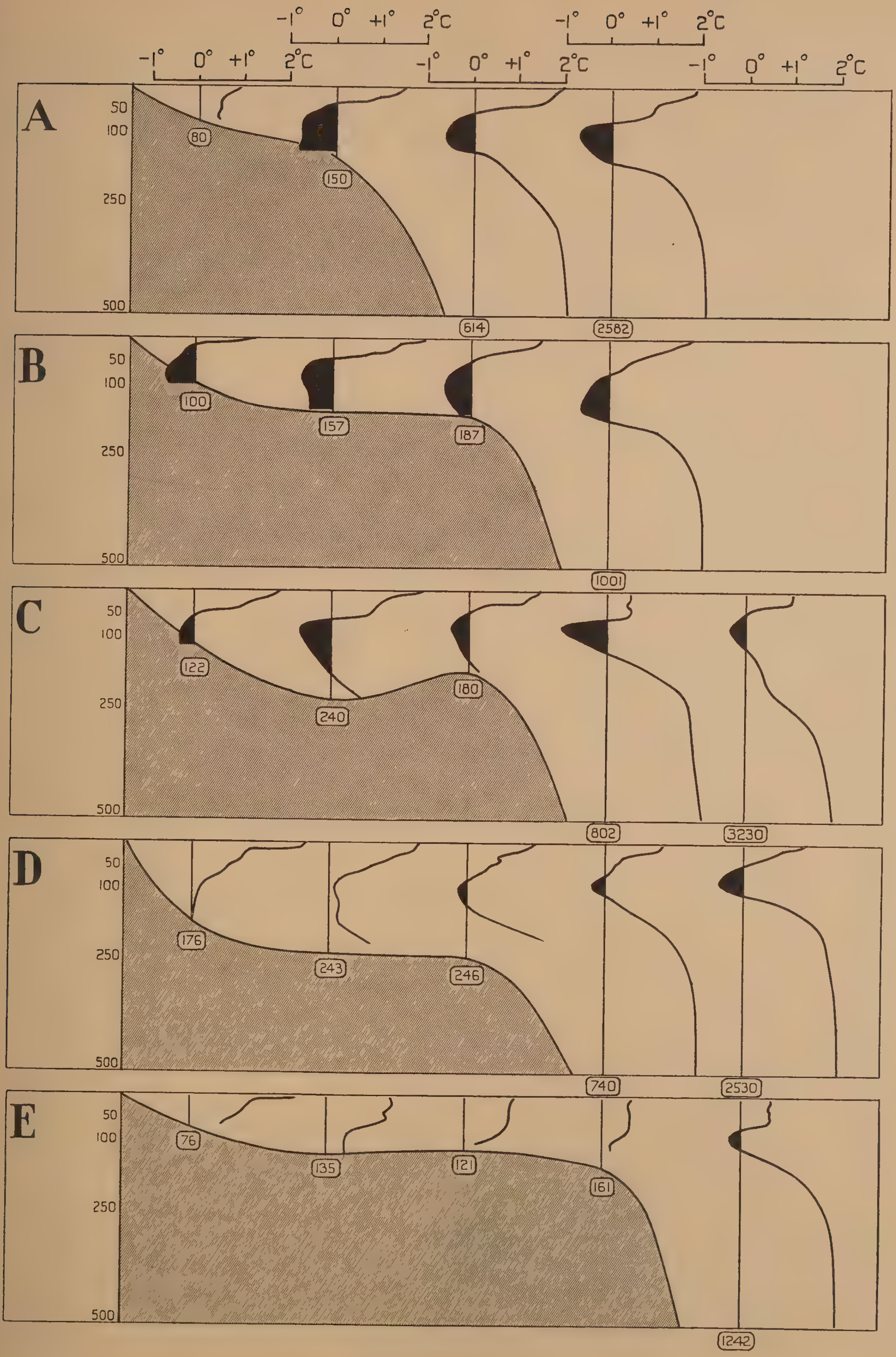
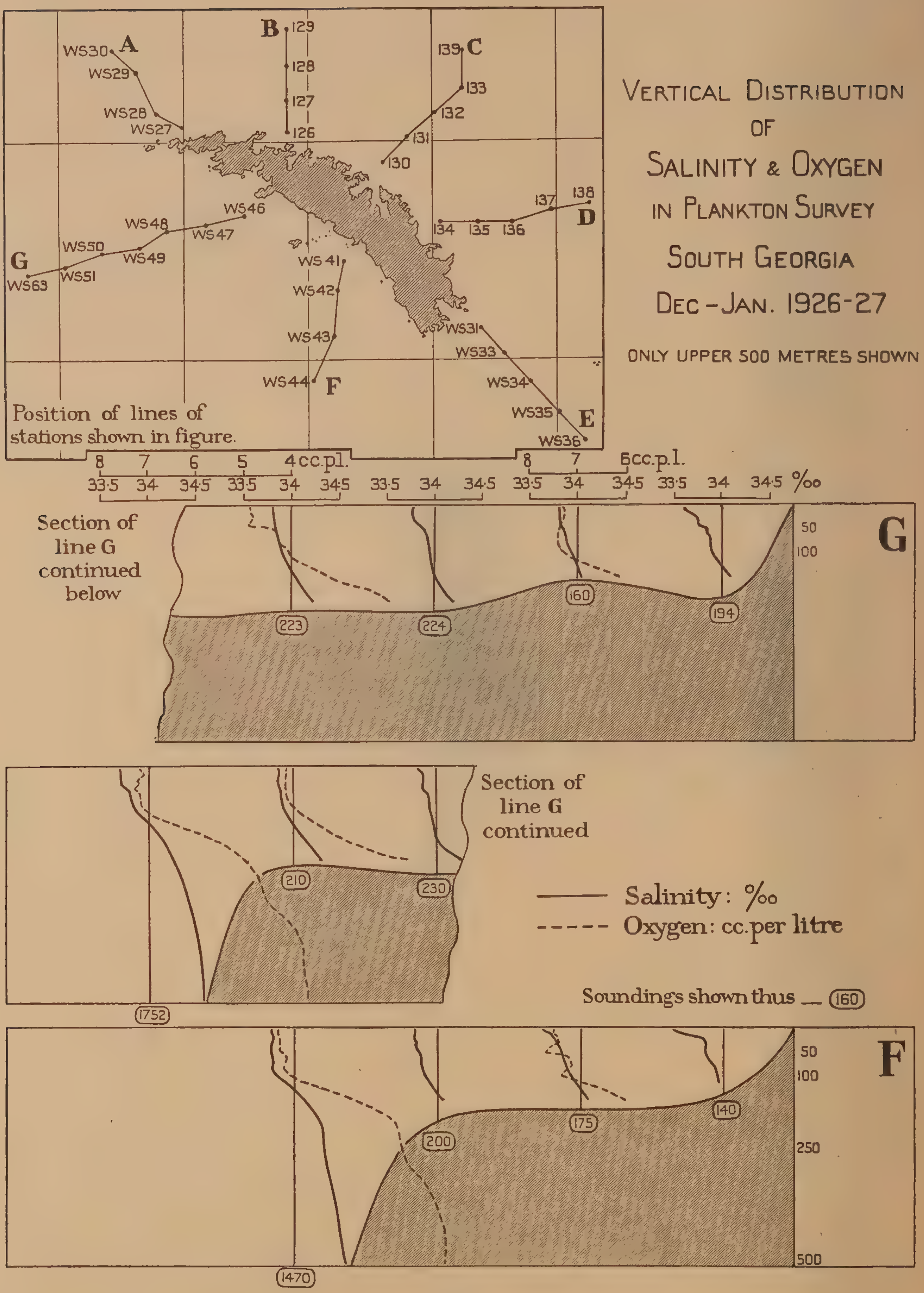


Fig. 7—*continued.*



VERTICAL DISTRIBUTION OF SALINITY & OXYGEN IN PLANKTON SURVEY SOUTH GEORGIA DEC-JAN. 1926-27

ONLY UPPER 500 METRES SHOWN

Position of lines of stations shown in figure.

Section of line G continued below

Section of line G continued

——— Salinity: ‰
- - - - Oxygen: cc. per litre

Soundings shown thus — (160)

Fig. 8.

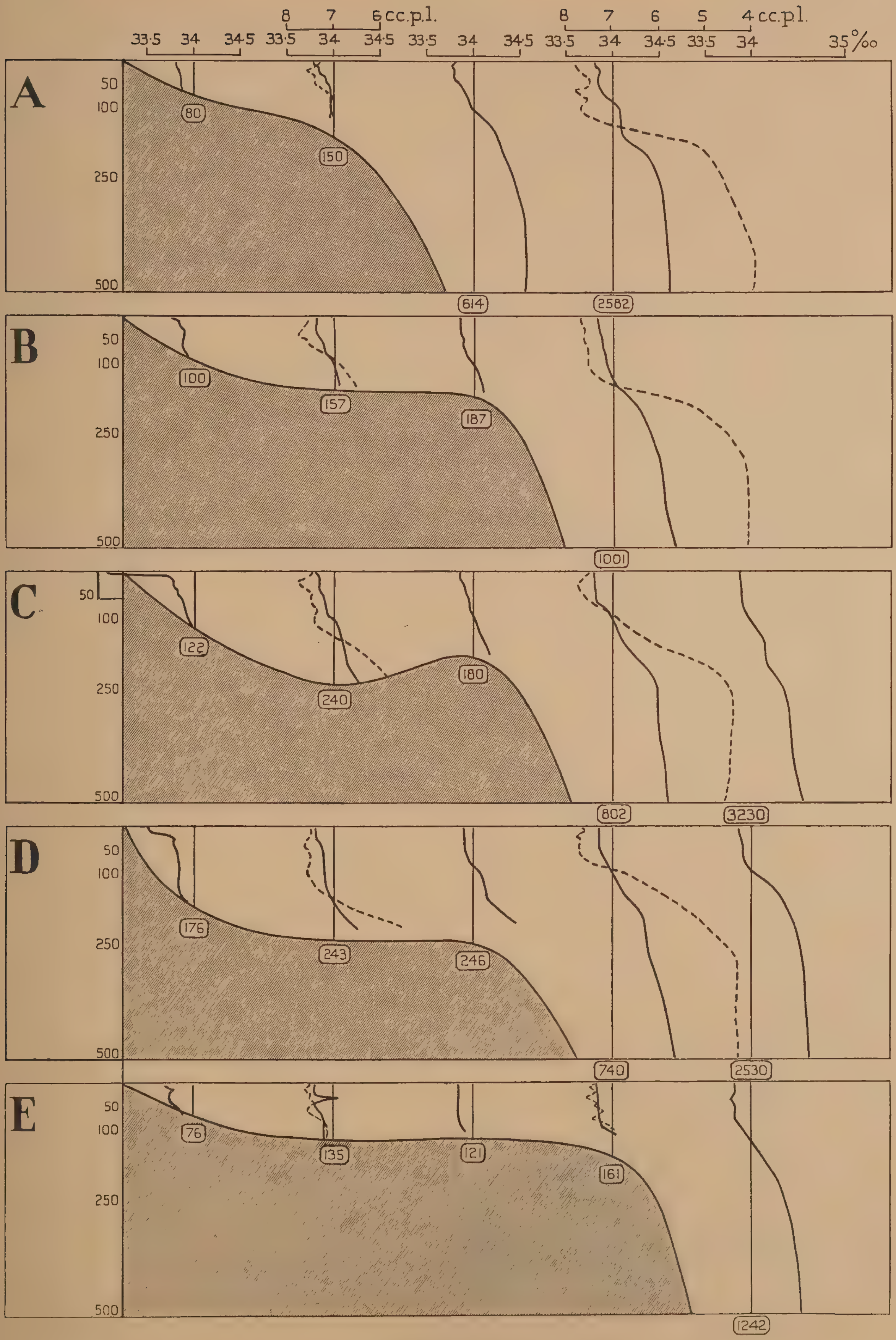


Fig. 8—*continued.*

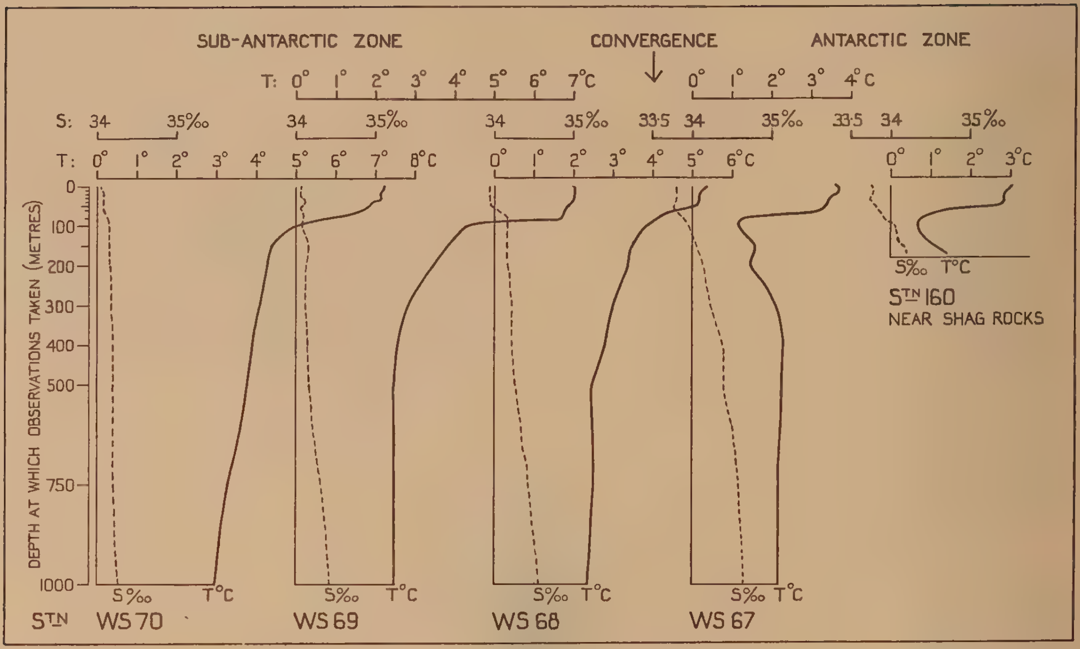


Fig. 9. Temperature and salinity-depth curves (labelled *T* and *S* respectively) at the plankton stations taken between the Falkland Islands and South Georgia in February 1927. For positions of stations see Fig. 14.

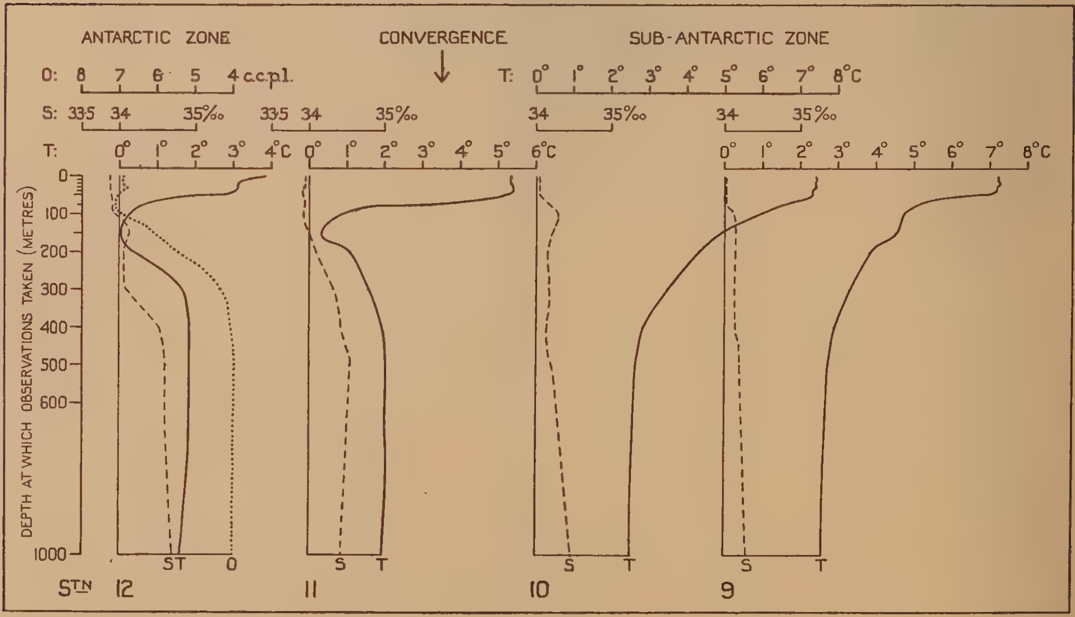


Fig. 10. Temperature and salinity-depth curves (labelled *T* and *S* respectively) at the plankton stations between South Georgia and Tristan da Cunha in February 1926. For positions of stations see Fig. 11. Oxygen content-depth curve (reversed scale) also shown at St. 12.

METHODS IN THE FIELD

The plankton samples were collected by three types of standard net: the 50 cm. diameter net which was hauled vertically and is referred to throughout as the "N 50 V", the 70 cm. diameter net referred to as the "N 70 V" or the "N 70 H" according to whether it was hauled vertically or horizontally, and the 100 cm. net which was used horizontally and is referred to as the "N 100 H". The results obtained with the Continuous Plankton Recorder are described in a separate paper to be published later; occasionally, however, the results obtained by this instrument will be referred to when they have a bearing upon the present work. The instrument at this period was used as an experimental rather than a routine method. A full description of the nets, illustrated with text-figures, and of the method of using them has already been published by Kemp and Hardy (1929) in vol. I of the *Discovery Reports*. For convenience, a brief summary of the principal features will be given here.

The N 50 V, designed for the capture of diatoms particularly and the smaller plankton forms generally, is made of the finest silk bolting cloth: that with 200 meshes to the linear inch. The front section of the net consists of a canvas cylinder 26 in. long and 50 cm. in diameter; this is attached to a galvanized iron ring of the same diameter and the ring is provided with three towing bridles. Behind the canvas cylinder is the net proper, it is 5 ft. 5 in. long and tapers from a 50 cm. diameter in front to a 6 cm. diameter behind, where it joins a small canvas cylinder, 7·5 cm. long, for attachment to the special brass collecting bucket. Wire stay ropes, 9 ft. long, similar to the bridles, extend downwards from the ring, assist in supporting the bucket and meet below to support a 7 lb. lead.[1]

The N 70 V, designed for the capture of the medium and smaller sized organisms of the macroplankton, from the small or young Euphausians and the largest Copepods downwards, is made with two grades of silk netting: 40 meshes to the inch in front and 74 behind. The galvanized iron ring has a diameter of 70 cm. At first, wire bridles were used, but when it was found that these sometimes fouled the closing mechanism they were replaced by rigid brass rods. From the ring extends a cylinder of coarse netting, 21 in. long, joined behind to a canvas band, 10 in. wide, furnished with brass rings to take the closing rope. The catching part of the net tapers from this band to a small canvas cylinder, 9 in. in circumference, for attachment to the brass bucket. This—the net proper—has a total length of 7 ft. 7 in. and is made in two sections: one 3 ft. 2 in. long of 40 meshes to the inch, and one behind 4 ft. 5 in. long of 74 meshes to the inch. Stay wires extend from the ring, assist in supporting the bucket and meet below to support a 40 lb. lead.

The net is closed by releasing the towing bridles from the closing mechanism and allowing the net to be caught and throttled by the closing rope passing through the rings round the canvas band described above.

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[1] Wire stay ropes have since appeared liable to chafe the silk of the net and in recent work they have been replaced by ropes of manilla.

The N 70 H net is the same as the N 70 V except that it has no weight or supporting wires and its bucket is of a simple light pattern. A different closing mechanism was used with the horizontal nets to that used for vertical nets: see Kemp and Hardy (1929).

The N 100 H, designed for the capture of macroplankton, particularly Euphausians and Amphipods, is also made of two grades of netting: 4 mm. mesh (knot to knot) in front and 15 meshes to the inch behind. The galvanized iron ring has a diameter of 100 cm. and is towed by three wire bridles. From the ring extends a cylinder of coarse mesh netting, 3½ ft. long, followed by a band of canvas, 6 in. wide, fitted with rings to take the closing rope. Joined to this is the catching part of the net, 10½ ft. long; it tapers from 100 cm. diameter (11 ft. in circumference) to join a canvas cylinder, 1 ft. 8 in. in circumference and 1 ft. long, for attachment to the bucket. The two sections of netting are 3½ ft. and 7 ft. long, of the coarser and the finer grade mesh respectively. Three supporting ropes run down the net to be fastened to the bucket. A closing rope passes through the rings on the canvas band.

A comparison of the composition of the respective catches of the three nets N 70 V, N 70 H and N 100 H is made in the zooplankton section on p. 92.

The stations worked by each of the two ships may be termed either *full routine stations* or *horizontal routine stations*.

At a *full routine station* the following procedure was carried out. The N 50 V net was lowered to a depth of 100 m. and then hauled open to the surface at a rate of 1 m. per second.[1] This gave a sample of the phytoplankton which is usually limited almost entirely to the upper 100 m. of water, although some interesting exceptions, of diatoms extending to much deeper layers, will be recorded. At the same time as the N 50 V was being used, or (if another winch was not available) immediately after it, a series of samples was taken with the N 70 V in the following order as deep as the sounding would allow: 50 m. to the surface, 100–50 m., 250–100 m., 500–250 m., 750–500 m., and 1000–750 m. In addition, at some stations hauls were made from 2000–1000 m. In each instance the net was hauled at a uniform speed of 1 m. per second[1] and closed by a releasing mechanism and throttling rope as the upper limit of the haul was reached. Whilst these samples were being taken with the nets, a vertical series of hydrological samples and observations was also being taken.

As soon as this vertical work was finished the ship steamed forward at a speed of 2 knots (approximately: 1 m. per second) and a series of three N 100 H nets was towed simultaneously on the same wire for a distance of 1 mile. The three nets were fastened to the wire, the deeper two by release mechanisms, at such distances apart as would allow the top net to fish just below the surface (0–5 m.), the middle net at a depth of about 50 m. and the bottom net at about 100 m. The maximum depth reached by the bottom net was recorded by the use of a Kelvin sounding tube attached to the towing rope just below the bottom net. At the end of the towing rope below the Kelvin tube was slung a stream-line lead of 56 lb. weight. At the end of the 1 mile tow, immediately before the nets were hauled in, the lower two nets were closed by sending a messenger

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[1] For methods of winding and counteracting the rolling of the ship, see Kemp and Hardy, 1929, p. 199.

(a brass sliding weight of special design) down the wire to operate the first closing mechanism which in turn released a second messenger to slide down the wire to close the bottom net. The actual times of closing were noted by placing a hand on the towing wire and feeling the shock of the messenger striking the closing mechanism. This series of N 100 H nets was immediately followed by a similar series of N 70 H nets towed and closed in exactly the same manner except that the length of tow was $\frac{1}{4}$ mile. This operation completed a full routine station.

At *horizontal routine stations* only the above procedure with the N 100 H and N 70 H nets was carried out.

The samples collected were taken to the laboratory, poured into glass jars, treated with formalin, labelled and allowed to settle. Formalin was added as soon as possible to these quantitative samples, otherwise if the sample contained a large number of carnivorous animals, such as Hyperiid Amphipods, its composition might be materially altered after a little time. When the sample had settled the excess fluid was filtered off and the bulk reduced to a convenient size for storage in small jars or tubes. Any organisms remaining on the filtering silk, which in all but the N 50 V samples was of a finer mesh than that used in collecting, were washed off into the sample.

When heavy catches of the larger organisms, such as Salps, Euphausians and *Parathemisto*, were taken, making the sample of unreasonable size, only a small fraction of the total would be kept: those thrown away were counted and their number recorded.

Whenever possible a preliminary examination of the sample would be made, together with an approximate estimate of its volume. At times, however, on account of the heavy rolling of the ship in these latitudes or lack of time, when stations followed one another in quick succession, not more than a cursory glance at the material could be taken. This is regrettable, but unavoidable when one is working at high speed to get through an extensive programme before another period of bad weather sets in. It is regrettable because when one comes to examine the samples in greater detail one often wishes one had just one more sample for confirmation or had altered the course of the ship a little or had extended the line of observations just a little farther on: the opportunity has gone for ever. It is important that the intervals in time between stations in a plankton survey should be as small as possible; it is also important to learn as much as possible of the results in the time available as one is going along.

DESCRIPTION OF CRUISES UNDERTAKEN

The cruises during which the plankton samples were taken may be briefly described in chronological order. Stations other than routine plankton stations will not be mentioned. The exact position of stations in latitude and longitude will not be given in the text; these with date, time and sounding are given in the tables in the Appendix; other details, including state of weather, sea and phase of moon, will be found tabulated in the Station List, 1925–7, *Discovery Reports*, vol. I, together with the hydrological observations.

In February 1926 the 'Discovery' approached South Georgia from the north-east, having come from South Africa via Tristan da Cunha. At Sts. 9, 10, 11 and 12 (see Fig. 11) N 70 V nets were used: at St. 9 down to 250 m., and at Sts. 10, 11 and 12 down to 500 m. The N 100 H net was used at the surface only at Sts. 8 and 9. Nearer to South Georgia a continuous plankton record was taken for a distance of 109 miles.

On account of the unfortunate but unavoidable delays in the start of the expedition, we arrived so late in the whaling season that we could not hope in this first instance to gain more than a provisional knowledge of the plankton of the whaling grounds, and to collect data which would be a guide in planning the more comprehensive survey of the following season. This work was made difficult and was much curtailed by the many successive gales and the fact that the 'Discovery' was not a full-powered ship. Early in March two lines of stations using N 70 V nets were made in a north-easterly direction from the coast (see Fig. 12): Sts. 13, 14, 15, 16 and 17 starting at a point 5 miles from the coast and with intervals of 10 miles between stations, and Sts. 18, 19, 20 and 21 also starting at 5 miles from the coast, but with intervals of only 5 miles between stations. In the middle of March a full station (St. 23) was taken at 5 miles from the coast, followed by another line of stations, 24, 25 and 26, at which the state of the sea made vertical work impossible, N 100 H nets only being used. St. 31 was a full station 13 miles off the coast.

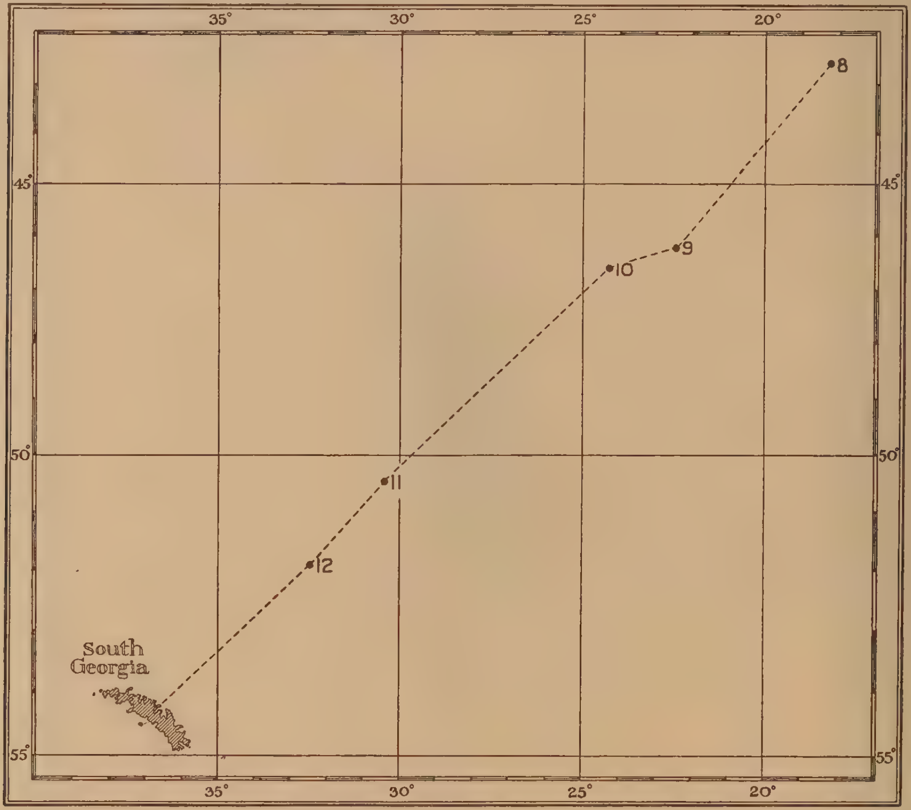

Fig. 11. Chart showing position of plankton stations taken when approaching South Georgia from Tristan da Cunha in February 1926.

Heavy weather again interfered with vertical work, and, since the N 100 H nets had been shown to be the most efficient for the capture of Euphausians, it was decided to run a series of N 100 H stations out from the coast and back again with a view to obtaining a knowledge of the distribution across the whaling area: Sts. 32–38 were accordingly made. Sts. 40, 41, 43 and 44 were also N 100 H stations. Following St. 41 the ship was anchored in a depth of 272 m., by means of the trawl warp, with the intention of making repeated vertical observations over a period of 24 hours, partly in order to study any changing conditions, including the vertical migration of the plankton, and partly to provide a control check upon the validity of the data obtained when single vertical observations were made.

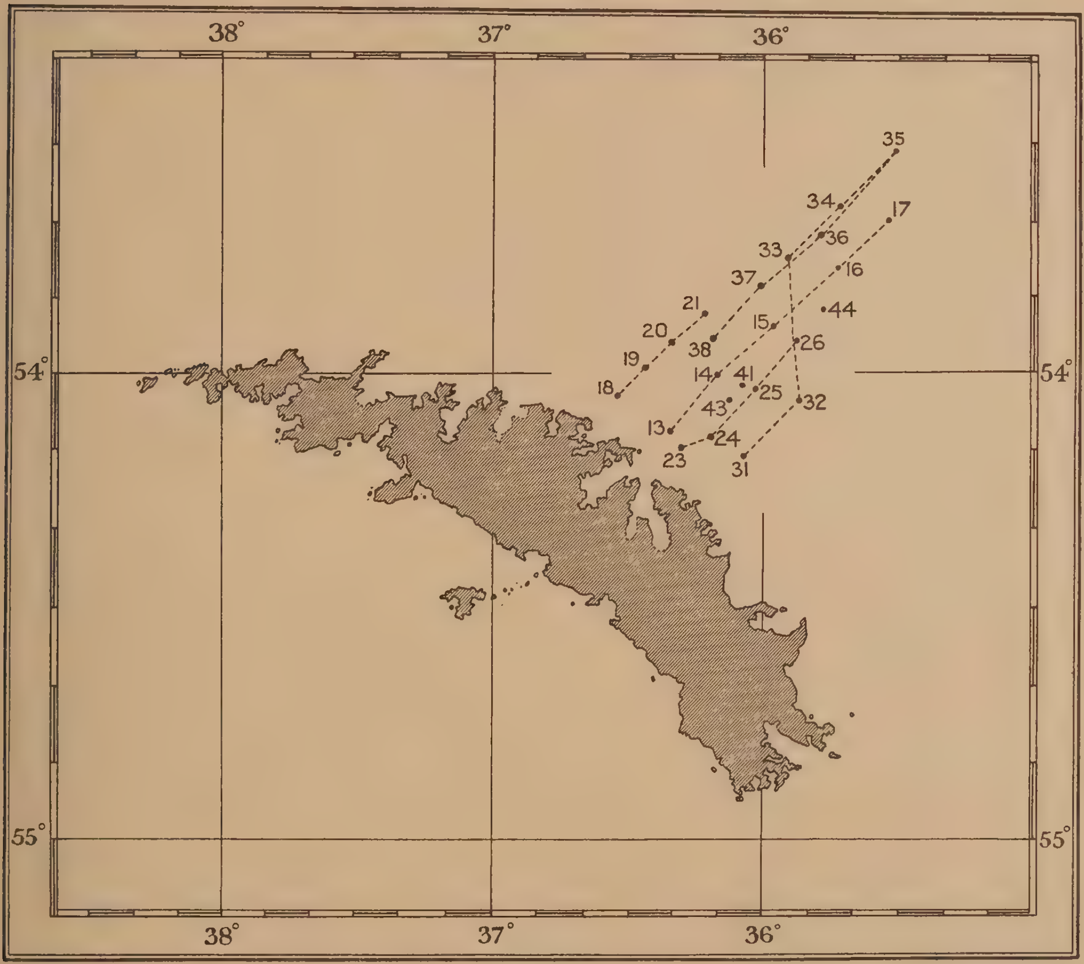

Fig. 12. Chart showing position of plankton stations taken at South Georgia in March and April 1926.

Vertical hauls were made at 1300 o'clock and repeated at 1600, 1700, 2000 and 2100 o'clock, when operations were terminated by the sudden onset of a gale. Continued rough weather prevented further plankton work until the ship sailed for the Falkland Islands on April 21.

Between South Georgia and the Falkland Islands two surface hauls with the N 100 H net were made at Sts. 46 and 47 (see Fig. 14).

In the following spring the 'William Scoresby', steaming direct from South Africa to South Georgia, arrived in November before the 'Discovery', which had taken the more southward course via Bouvet Island. From November 26 to 30, the 'William Scoresby' ran a line of five full routine stations (except N 50 V nets), WS 18–22, at 10-mile intervals in a north-east direction from Larsen Point, the first station being 5 miles from the land (in positions corresponding to those on the C line in Fig. 13).

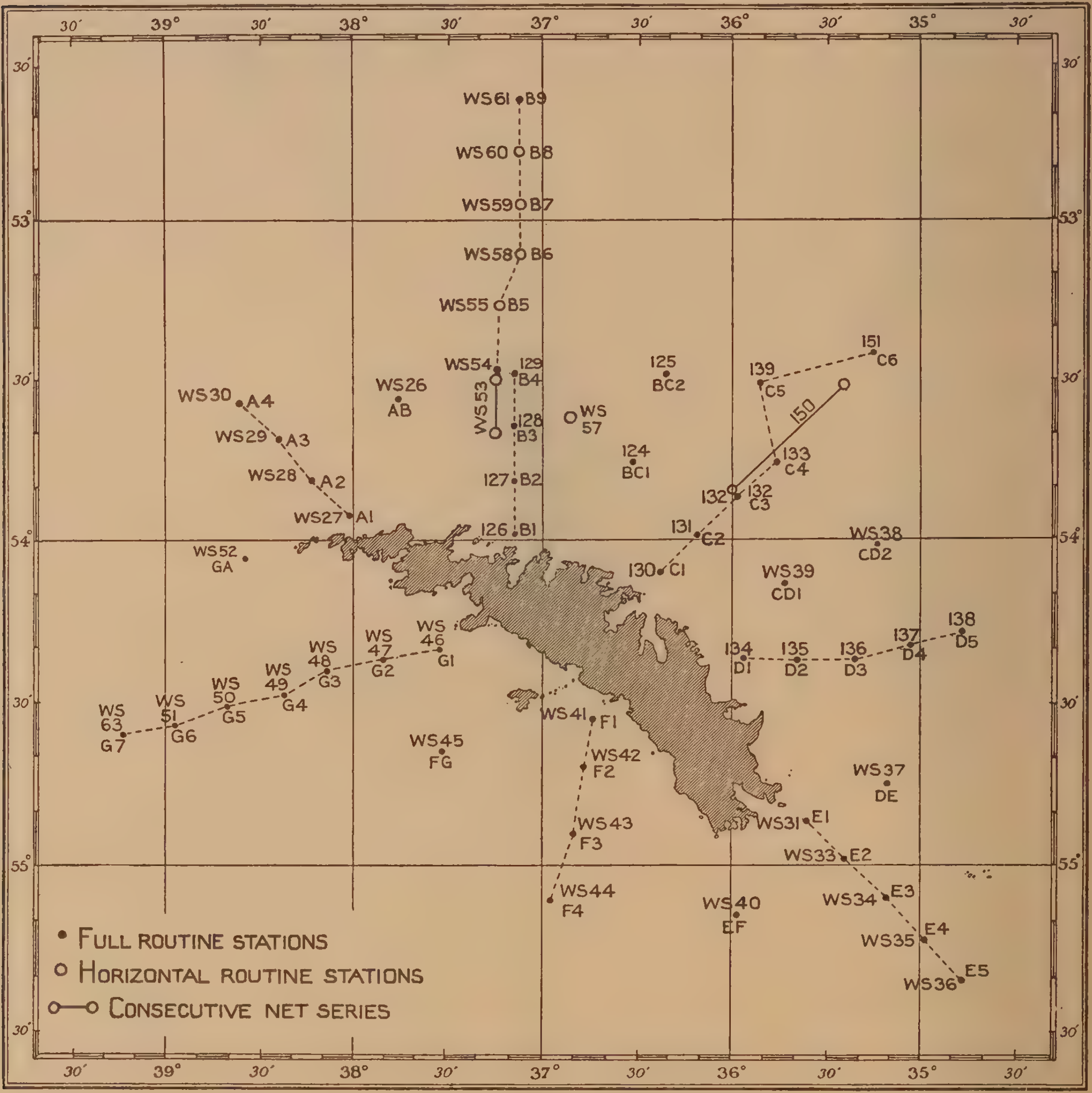
30′
39°
30′
38°
30′
37°
30′
36°
30′
35°
30′
53°
54°
55°
WS61 B9
WS60 B8
WS59 B7
WS58 B6
WS55 B5
WS54
129 B4
WS 53
128 B3
127 B2
126 B1
WS 57
WS26 AB
WS30 A4
WS29 A3
WS28 A2
WS27 A1
WS52 GA
125 BC2
124 BC1
151 C6
139 C5
150
133 C4
132 C3
131 C2
130 C1
WS38 CD2
WS39 CD1
138 D5
137 D4
134 D1
135 D2
136 D3
WS 46 G1
WS 47 G2
WS 48 G3
WS 49 G4
WS 50 G5
WS 51 G6
WS 63 G7
WS45 FG
WS41 F1
WS42 F2
WS43 F3
WS44 F4
WS37 DE
WS31 E1
WS33 E2
WS34 E3
WS35 E4
WS36 E5
WS40 EF
• Full routine stations
○ Horizontal routine stations
○—○ Consecutive net series

Fig. 13. Chart showing the position of stations in the South Georgia plankton survey, December–January 1926–7.

After the arrival of the 'Discovery' the first main survey of the waters round South Georgia was carried out by the two ships during December and January. It was decided first to cover the area off the north-east side of the island in which most of the whaling takes place. To do this five lines of "full routine" stations were planned (see Fig. 13): line A running north-west of Bird Island, the most northerly point of South Georgia; line B due north from Prince Olaf Light; line C north-east from Larsen Point; line D due east of Cape Vakop; and line E south-east from Cooper Island off the southern end of South Georgia. The stations along each line were arranged at 10-mile intervals, the first being at a point 5 miles from the coast and the last when soundings of 1000 m. or more were met with, each line being limited to six stations. The stations have their proper sequence numbers, e.g. 124, 125, 126, etc., or WS 26, 27, 28, etc., according to whether they were taken by the 'Discovery' or 'William Scoresby', respectively; but it will be convenient in discussing the results of the survey to refer to them also as stations A 1, A 2, A 3, ..., B 1, B 2, B 3, ..., etc., according to the line to which they belong and numbering out from the coast. Stations were also arranged in intermediate positions between the lines: AB, BC 1 and BC 2, CD 1 and CD 2, and DE between the lines indicated by the lettering. This programme, which was shared between the two ships working simultaneously and continuously, was completed within a week, from December 17 to 23.

After making a rapid examination of the material collected, four pieces of work appeared necessary to complete the survey:

(i) To carry out similar lines of stations on the other side of the island, to the west and south-west, with intermediate stations to complete the picture of conditions around the island.

(ii) To continue line B, at the end of which quantities of krill (*Euphausia superba*) had been taken over deep water, to see how far the krill extends beyond the coastal slopes.

(iii) To carry out one or more continuous series of consecutively towed nets to determine the frequency, size and density of the patches of krill and other large organisms; this patchiness was indicated by tow-nettings taken at previous stations. This was considered of great importance in that it would form a "control" to determine the reliance that could be placed upon observations made by a single net. *E. superba* is too large to be satisfactorily recorded on the Continuous Plankton Recorder.

(iv) To take current measurements at each end of the island to determine the rate of the drift of the water carrying the plankton, an indication of movement about the island having been suggested by the preliminary examination of the material.

This programme was delayed by weather and other causes, but was completed between January 6 and 23, except that only one set of current measurements at the north-west end of the island could be taken. Two lines of full routine stations were taken: line F running S 15° W from Pickersgill Island with F 1 between this island and the mainland, and line G running S 75° W from Cape Nunez. Line G was extended to G 7, stations G 1 to G 6 being all in shallow water. Intermediate stations were made at EF, FG and GA. The B line was extended to B 9 by taking horizontal routine stations at B 6, B 7 and B 8, and a full routine station at B 9. B 5 was repeated as a full station down to 500 m. depth. Two series of consecutive net hauls were taken: one of 23 hauls and one of 51 hauls.

On February 6, the 'Discovery' sailed for the South Orkneys and the Bransfield Straits taking full routine stations 160 and 161 to the west and south-west of South Georgia; the remaining stations on her voyage farther south are not included in the present report. The 'William Scoresby' sailed for the Falkland Islands on February 17 taking a horizontal routine station at 66 and full routine stations at 67, 68, 69 and 70 on the way (see Fig. 14).

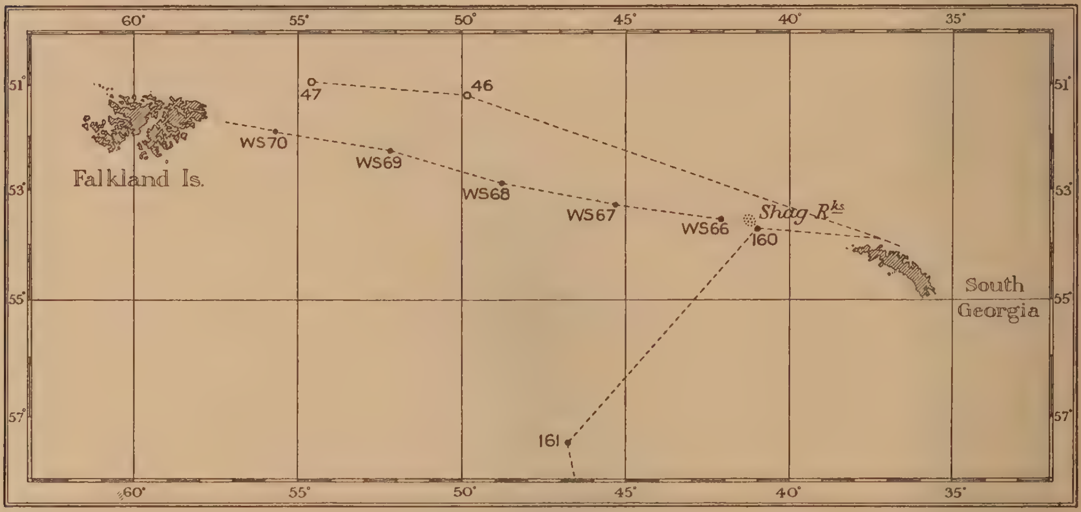

Fig. 14. Chart showing the position of plankton stations between South Georgia and the Falkland Islands. Sts. 46–47 taken in April 1926, remainder in February 1927.

At the end of May the 'William Scoresby' returned to South Georgia before running a line of stations across the Southern Ocean to Cape Town; here she repeated the five stations on the C line of the survey to compare with conditions found on this line on previous occasions in November, December and March of the previous year.

It should be remembered that in planning the positions of the stations in all this early work, we were without any knowledge of the hydrological conditions such as is outlined in the previous section. The data on which this knowledge is based were collected at the same time as the plankton, and only subsequently, after their analysis and correlation, was this picture of the hydrological conditions round South Georgia obtained.

LABORATORY METHODS AND THEIR ACCURACY

It will be convenient to describe the methods used in the analysis of the different plankton samples separately under the headings of the different nets.

Analysis of N 50 V samples

The N 50 V net was used specially for the capture of diatoms and other phyto- and microplanktonic organisms. Since the N 70 V net captures the medium-sized organisms more efficiently, and was used through the same range of depth as the N 50 V at each station, the method of analysis of samples caught by the N 50 V was not designed to take proper account of the few Copepods, young Euphausians and Chaetognatha which might also be taken. The proper estimation of these is left to the analysis of the N 70 V samples.

First of all any large organisms such as Salps, Ctenophores, Euphausians, Amphipods and the larger Copepods were picked out. Then the volume of the sample was measured after it had been allowed to settle for at least 24 hours in a measuring jar. The volumes ranged from 1·5 cc. to as much as 290 cc. An estimate of the volume is, however, of very little value, since some organisms with long spines such as *Chaetoceros* and *Corethron* tend to settle together more loosely than do forms with not such long spines. When the sample contained no large organisms the volume could be measured by noting the height of the column of plankton in the tube on a scale placed at the side, and then replacing the plankton by an equal quantity of water the volume of which could be subsequently measured. This method avoided the unsettling and resettling of the sample.

By the addition of water the sample or a particular fraction of it was now diluted up to a definite volume—50 cc., 100 cc. or 150 cc., according to its bulk—placed in a spherical flask and sampled by a 0·5 cc. stempel pipette. The fraction so taken for examination usually ranged from 1/100 to 1/300 according to the density of the sample, but with much larger samples a further dilution was necessary, in extreme instances bringing the fraction examined to but 1/3000 of the total sample. The contents of the stempel pipette were now discharged upon a special slide ruled into small squares by lines 2 mm. apart and provided at its edges with a raised glass rim (see Fig. 15). This is now moved under the microscope by means of the Murray long-range mechanical stage,[1] so that one row of squares after another can be examined until the whole area is

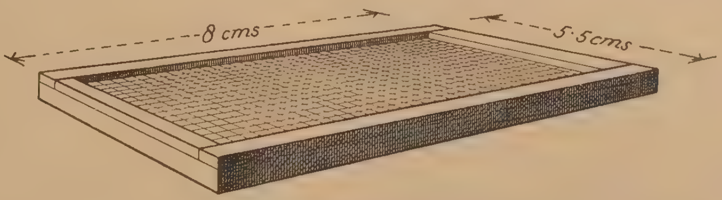

Fig. 15. Counting slide used in the analysis of phytoplankton samples.

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[1] Made by Messrs Watson and Sons, Holborn.

covered. A $\frac{2}{3}$-in. objective conveniently covers the width of the 2 mm. squares; but a $\frac{1}{6}$-in. objective has continually to be brought into use. If a large number of very small forms are present it will be necessary to travel backwards and forwards over each individual square with the $\frac{1}{6}$-in. objective; this can be done without covering the same ground twice by using a grid form of micrometer eyepiece and counting the number of organisms viewed through the grid, and then moving the slide until another portion of the square comes below the grid. A particular organism or mark on the slide lying under the right side of the grid is kept under observation and the slide moved until it comes to lie on the left. If small organisms are very numerous it will only be possible to count those present in a limited number of squares taken at random over the slide. By taking the average in these squares and multiplying by the appropriate factor an estimate of the total number on the slide is obtained.

Accuracy of N 50 V analysis methods

Usually only one fraction of a sample collected has been analysed. A number of such fractions might have been analysed for each sample and their average taken; but we do not believe that the time taken in gaining a more accurate estimate of the contents of the sample is justified when we know that the methods of collection are necessarily only giving us an approximate indication of the plankton in the vicinity of the station.

In order to estimate the degree of reliance which can be placed on the analysis of single fractions, six such fractions were taken from a single sample collected at St. 133 and analysed for five different diatoms which varied considerably in size and shape. The fraction of the sample examined in each instance was 1/600.

The results are tabulated as follows:

	Species				
	Corethron valdiviae	*Rhizosolenia styliformis*	*Coscinodiscus bouvet*	*Chaetoceros criophilus*	*Nitzschia seriata*
	36,600	9,000	8,400	97,200	48,000
	24,600	11,400	15,000	83,400	39,000
	39,600	7,200	16,800	133,200	78,600
	35,400	8,400	17,400	87,600	83,400
	28,200	5,400	18,600	97,800	64,800
	42,000	7,200	21,000	126,000	76,200
Mean	38,800	8,100	16,200	104,200	65,000
Mean deviation ...	5,733	1,500	2,933	16,933	14,400
Maximum deviation ...	14,200	3,300	7,800	29,000	26,000
Maximum deviation as percentage of mean ...	36·6	42	48·1	27·8	40
Mean deviation as percentage of mean ...	14·8	18·5	18·1	16·2	22·2

Thus we see that the result of an analysis of a single fraction is usually 18 per cent larger or smaller than the true content of the samples and it may in exceptional instances be as much as nearly 50 per cent larger or smaller. These facts must be kept in mind in interpreting the results which follow and will be referred to from time to time in the later text. Thus, when studying the distribution of any form, should we see 30,000 of a particular diatom recorded for a station we must recognize that it is possible that the figure may actually be 15,000 or 45,000. At first sight this may appear to be a very large degree of error, but when the variation in numbers of any diatom round South Georgia is seen, it will be realized that this possible source of error is of little significance. For example *Corethron valdiviae* is recorded as occurring in the following numbers at six different stations:

10,866,000 (the largest number recorded)
1,004,000
562,000
61,000
5,000
200 (the smallest number recorded)

We are in this work concerning ourselves only with the big differences; the very nature of the distribution of the plankton we are studying and the necessary limitations to our methods in the field will not allow us to attempt the establishment of small differences. When we are comparing one region represented by 5000 *Corethron* with another represented by 562,000, what does it matter if that 5000 is really 7500 or 2500, or again if the 562,000 is really 281,000 or 743,000? In the very unlikely event of both the figures which are being compared erring in opposite directions to the exceptional amount of 50 per cent the difference in the resulting comparisons is very small: e.g. 2500 is 0·3 per cent of 743,000, but also 7500 is only 2·6 per cent of 281,000.

Similarly, when we compare an area represented by 61,000 with another represented by 10,866,000, what does it matter if the former is 90,500 or 30,500 or the latter 5,433,000 or 16,299,000? The smaller value of the former can be expressed as 0·2 per cent of the larger value of the latter, whilst the larger value of the former is but 1·8 per cent of the smaller value of the latter.

When very small numbers are recorded in the analysis their actual value should not be regarded as significant—they merely indicate the presence of the organism in small numbers. For example, if the fraction of the sample examined is 1/600, and only one of a particular organism is taken up in this fraction by the pipette, it will figure as 600.

Analysis of N 70 V samples

Firstly the volume of each sample was measured by methods similar to those just described for the N 50 V samples; but volume, as with the N 50 V samples, gives only a very rough indication of the relative bulk of the different samples on account of the varying settling and packing properties of the different organisms.

Next all the larger organisms were picked out and recorded: Medusae, Siphonophora, the larger Chaetognatha, the larger Calanoid Copepoda, Mysidae, Amphipoda, Euphausiacea, Pteropoda, etc. These are organisms which on account of their size are not likely to be fairly sampled by the stempel pipette, and they are picked out as well as recorded at this stage, since they tend to entangle the smaller organisms and so encumber analysis of the fraction of the sample later examined. As a general rule Calanoid Copepoda of more than 2 mm. in length were picked out at this stage; but if, as sometimes happened, they occurred in sufficiently large numbers to be fairly sampled by the pipette, i.e. over 200, they might be left in.

Next the sample was examined for smaller but rarer organisms, which on account of their small number would not be fairly sampled by the pipette. These, which may include Radiolaria, Foraminifera, small Chaetognatha, Polychaeta, rare Copepoda, Ostracoda, Euphausiid larvae, Pteropoda and Appendicularia, are also picked out and recorded. All the organisms picked out were separated into genera and preserved in separate tubes, so that they were readily accessible for reference by ourselves and for subsequent examination by specialists in different groups.

The volume of the residue, after the larger organisms had been picked out, was again measured after allowing the sample to settle in a measuring jar for at least 24 hours.

In some instances this residue was small enough to be analysed as a whole, but usually a fraction only could be taken. The fraction for analysis was taken by means of the stempel pipette and flask as in the N 50 V samples, but the fractions taken were larger. This stempel method and apparatus is described by Hensen (1887, 1895). The most convenient fractions for examination were 1/20, 1/40 and 1/60, and were taken by using a 2·5 cc. pipette after diluting the sample to 50, 100 and 150 cc. respectively in stempel flasks of corresponding sizes. The amount of dilution employed depended upon the nature of the sample. Other fractions from 1/20 to 1/150 were obtained by using 5 cc. or 1 cc. pipettes, and smaller fractions still by halving the sample before diluting. In determining the size of the fraction to be examined it was decided that there must be contained in the fraction at least 100 of the commonest animal species present. Actually in practice the number of the commonest animal in the fraction examined was often more than double this amount. Choice of a suitable fraction was further influenced by the relative abundance of larger and smaller organisms in the sample. For example, in exceptionally bulky samples where large Calanoid Copepoda and small Oithonid Copepoda might occur in numbers of over 500 and 5000 respectively, the residue was more accurately and speedily analysed by taking two fractions: one with a 5 cc. or 2·5 cc. pipette for the larger organisms, and one with a smaller pipette or greater dilution for the smaller organisms. When shaking up the sample immediately before sampling with the pipette, particular care must be taken to get an even mixture and to counteract the effects of gravity and centrifugal force. This applies to the N 50 V samples as well.

The quantity of liquid taken up by the pipette in separating these fractions from the sample is often too great for convenient handling on the special microscope slide, and the excess is preferably drained away before the pipette is discharged. This is easily done by allowing the pipette to stand inverted, until all the organisms have settled on the roof of the plunger. The pipette is now opened slightly so that the superfluous liquid, which is held back by surface tension, may be drawn away slowly, either by a light pipette or blotting paper, without disturbing the settled plankton. The pipette is now closed and the contents are shaken round and discharged and spread out on the slide.

The slide is similar to that shown in Fig. 15, only larger and with every fifth line slightly thicker than the rest making squares of 1 cm. as well as the small squares of 2 mm. It is passed to and fro below the microscope by the Murray long-range mechanical stage until the analysis is complete. Diatoms if present in overwhelming numbers are counted on a restricted number of squares selected at random from different parts of the slide and the quota calculated. Only the common outstanding species of diatoms were identified in the N 70 V samples, since they are better sampled by the N 50 V net in the analysis of which they are treated in greater detail; important records of diatoms at levels below that at which the N 50 V was fished were, however, obtained by the N 70 V nets.

Analysis of N 70 H samples

The N 70 H is made to a similar specification to that of the N 70 V, but was towed for a distance of ¼ mile (402 m.) through the upper layers of the water which are sampled by hauls with the N 70 V of only 50 m. vertical distance. They therefore caught samples of greater size, and a modification in the method of analysis was made by Mr Andrew Scott. After the larger organisms had been picked out and recorded the sample was washed through a sieve which retained the majority of the catch, including most of the Copepoda, but allowed the very small organisms, diatoms, Protozoa and the smaller Copepoda, to pass through. The volumes of the two portions of plankton so obtained were measured and then each portion sampled with a stempel pipette and analysed as in the N 70 V samples. A fraction of 1/120 was usually taken from the portion containing the larger organisms, by taking up 1/60 with the pipette from half its volume. A larger fraction was usually taken from the portion containing the smaller organisms, for the quantity was also usually much smaller.

Analysis of N 100 H samples

This net, designed for the capture of the larger plankton organisms only, allows the smaller forms to pass through its meshes. Here the method of analysis is simpler, the examination being carried out usually with a simple microscope. When the sample is of reasonable size the whole is counted, the sample being spread out on a Petri dish placed over a disc divided into alternate black and white octants. With larger samples only half or a quarter would be examined in this way. Catches with this net were sometimes very heavy, as when numbers of Euphausians, Amphipods, or Salps were taken, amounting at times to a volume of some 20 litres. In such cases the majority of the organisms would be picked out, counted and recorded on board ship and then thrown away, leaving a small sample for subsequent examination and reference. In instances of very heavy pure catches of one organism, such as occurred with *Euphausia superba* and *Parathemisto gaudichaudi*, their number would be estimated by displacement methods after counting the number of organisms displacing a given volume of water.

Validity of the N 70 V and N 70 H analysis methods

As a rule, after the larger and rarer organisms had been picked out, only one fraction per sample was examined unless, as already explained, the nature of the sample—e.g. one containing large quantities of both big and little organisms—made the use of two fractions necessary.

It was felt that the closer approach to accuracy in estimation obtained by analysing several fractions from each sample and then taking their average was not justified, on account of the unavoidable error involved in our methods in the field. When we remember that we are comparing stations in a survey one part of which took a week to complete, and the remaining part of which was only completed after an interval of three weeks, and when we know that the ocean currents and wind at the surface are constantly moving the plankton, we must realize that the values obtained at different stations represent no more than a very general approximation to that which they would have if all the stations compared had been taken simultaneously. In considering any survey we must imagine that we are comparing results of one part with those of another at the same point in time.

We know too that many organisms are very "patchy" in their occurrence instead of being evenly distributed for many miles together. At St. 41 a series of vertical hauls with the N 70 V closing net were made from the bottom to the top (265–150 m., 150–100 m., 100–50 m., and 50 m. to the surface), and this series was repeated five times during a period of eight hours at 1300, 1540, 1700, 1910 and 2105 o'clock respectively. Whilst some organisms showed a variation over this period of time no greater than the variation due to error in laboratory methods, the Copepods *Ctenocalanus vanus*, *Drepanopus pectinatus*, *Oncea curvata* and *Oithona frigida*, showed a range of variation greatly exceeding the error in laboratory methods. These results will be further discussed in the Zooplankton section on p. 263. We may here tabulate the results for the four species just named, expressed as numbers per 50 m. haul for each of the five series of hauls or their average.

	Average of the five series	Maximum number of the five series	Minimum number of the five series	Time of max.	Time of min.
Ctenocalanus vanus	748	1445 = + 95 % of av.	260 = − 65 % of av.	1300	2105
Drepanopus pectinatus	1713	2832 = + 65 % ,,	651 = − 62 % ,,	1700	1300
Oncea curvata	155	324 = + 109 % ,,	40 = − 74 % ,,	1300	1540
Oithona frigida	3942	6947 = + 74 % ,,	1138 = − 71 % ,,	1910	1540

It will be seen that had we taken only one series of vertical hauls at this station, as was the case throughout the rest of the survey, we should have recorded 1445 *Ctenocalanus vanus* per 50 m. haul at 1300 o'clock, and only 260 if we had arrived on the station eight hours later, or again 651 *Drepanopus pectinatus* at 1300 o'clock and 2832 if we had arrived on the station only four hours later. These differences, since the hauls are taken from just above the bottom to the surface, are independent of changes due to vertical migration, unless some of the organisms are actually resting for part of the time on, or within a few feet of, the bottom; but whether this be so or not it would be a condition which might apply to any stations taken from the bottom to the surface throughout the survey.

Since we know that many of our stations are separated by considerable intervals of time we can only take into account the very big differences in the number of organisms when comparing one region of the survey with that of another. This being so it is surely unwise to attempt a closer approach to accuracy in the laboratory than that afforded by taking only one fraction from each sample for analysis when we know that the very nature of the samples we are examining will not warrant it. Further, under these conditions we did not feel that we could justify the additional time taken by trebling the analyses of some 800 samples when the masses of material from later surveys were mounting up and awaiting the attention of our limited staff. It is our task to compare the broad differences between region and region and season and season.

The error in the laboratory due to taking only a fraction of the sample and estimating the total numbers present in the sample is less for the smaller organisms, which are more easily sampled by the pipette, than for the larger organisms. We will consider the error involved in estimating the numbers of seven organisms of different sizes: Foraminifera, *Oithona*, small Calanoid Copepoda (including such forms as *Ctenocalanus* and *Drepanopus*), medium-sized Calanoid Copepoda (including such forms as *Metridia* and *Clausocalanus*), *Calanus* spp., *Rhincalanus gigas*, and Chaetognatha.

Two samples were sub-sampled, each twelve times, to estimate the numbers of *Oithona*, small Calanoids and medium Calanoids in them. They were one N 70 H net sample from St. 121, and one N 70 V net sample from the station above referred to as giving us evidence of patchiness: 41 D 150–100 m. The former sample was also used for determining the error involved in estimating the number of Foraminifera.

Foraminifera

Foraminifera showed an especial tendency to be unfairly sampled, for owing to their relatively high specific gravity and compact shape, they sink rapidly like grains of sand and are liable to escape the stempel pipette. The larger colonial Radiolaria were also difficult to estimate, since they tend to stick together so that they are not so evenly distributed throughout the sample as other forms and consequently give a larger error. Whenever possible these were picked out and counted separately before the sample was fractioned, but where they occurred in large numbers the stempel pipette was used.

The numbers estimated from sub-sampling the St. 121 sample were as follows:

Sub-samples	1/40	of whole sample	1600	880	1840
,,	1/50	,, ,,	2200	1100	1050
,,	1/60	,, ,,	840	600	720
,,	1/100	,, ,,	800	700	200

giving a mean of 1044.

Six out of these twelve sub-samples give a range of variation from this mean of from – 31 to + 5 per cent.

Nine out of these twelve sub-samples give a range of variation from this mean of from – 42 to + 53 per cent.

The twelve sub-samples give a range of variation from this mean of from – 81 to + 111 per cent.

Thus in the majority of instances the error is of the order of 50 per cent but may be as high as 100 per cent or over. The mean variation is 41 per cent of the mean.

Oithona

The numbers estimated from sub-sampling the St. 121 sample were as follows:

Sub-samples	1/40	of whole sample	18,080	14,960	16,640
,,	1/50	,, ,,	15,100	18,700	12,200
,,	1/60	,, ,,	17,640	16,800	12,800
,,	1/100	,, ,,	16,200	14,600	15,200

giving a mean of 15,660.

Six out of these twelve sub-samples give a range of variation from this mean of from – 7 to + 6 per cent.

Nine out of these twelve sub-samples give a range of variation from this mean of from – 7 to + 15 per cent.

The twelve sub-samples give a range of variation from this mean of from – 22 to + 18 per cent.

The sub-sampling of the St. 41 D sample gave similar results:

Sub-samples	1/40	of whole sample	4040	4160	3480
			3040	3520	4240
,,	1/60	,, ,,	3742	3862	4042
			4342	4162	3162

giving a mean of 3816.

Six out of these twelve sub-samples give a range of variation from this mean of from – 7 to + 9 per cent.

Nine out of these twelve sub-samples give a range of variation from this mean of from – 17 to + 11 per cent.

The twelve sub-samples give a range of variation from this mean of from – 21 to + 13 per cent.

The fractions employed in the sub-sampling are those most frequently used in practice. No doubt over the whole survey somewhat larger variations will occur, but we may take it that when large numbers are concerned the majority of instances will have an error of about 15 per cent and a minority with as much as 25 per cent. When very small numbers are concerned no reliance can be placed upon the figure; it is merely an indication of the presence of the organism in the sample; this applies to all organisms.

Small Calanoids

The numbers estimated from the sub-sampling of the St. 121 sample were as follows:

Sub-samples	1/40	of whole sample	3840	3200	3440
,,	1/50	,, ,,	2700	3000	3350
,,	1/60	,, ,,	2880	2400	2640
,,	1/100	,, ,,	2600	2400	4400

giving a mean of 3071.

Six out of these twelve sub-samples give a range of variation from this mean of from – 12 to + 15 per cent.

Nine out of these twelve sub-samples give a range of variation from this mean of from – 15 to + 25 per cent.

The twelve sub-samples give a range of variation from this mean of from – 21 to + 43 per cent.

In routine practice when taking a sub-sample with the pipette one is generally able to tell when one has taken a sub-sample which is giving an exceptionally high or low result, and the pipette is then emptied and another sub-sample taken.

The sub-sampling of the St. 41 D sample gave similar results:

Sub-samples	1/40	of whole sample	760	1000	1000
			1120	840	1000
,,	1/60	,, ,,	660	780	900
			840	960	720

giving a mean of 810.

Six out of these twelve sub-samples give a range of variation from this mean of from – 12 to + 13 per cent.

Nine out of these twelve sub-samples give a range of variation from this mean of from – 18 to + 13 per cent.

The twelve sub-samples give a range of variation from this mean of from – 25 to + 27 per cent.

Whilst no doubt over the whole survey somewhat larger variations will occasionally occur we may take it that in the majority of instances the error will not exceed 25 per cent.

Medium Calanoids

The numbers estimated from the sub-sampling of the St. 121 sample were as follows:

Sub-samples	1/40	of whole sample	1840	2080	1520
,,	1/50	,, ,,	2600	2700	2000
,,	1/60	,, ,,	3000	1800	1860
,,	1/100	,, ,,	2600	1300	1400

giving a mean of 2058.

Six out of these twelve sub-samples give a range of variation from this mean of from – 26 to + 1 per cent.

Nine out of these twelve sub-samples give a range of variation from this mean of from – 32 to + 26 per cent.

The twelve sub-samples give a range of variation from this mean of from – 37 to + 45 per cent.

The sub-sampling of the St. 41 D sample gave somewhat similar results:

Sub-samples 1/40 of whole sample	1280	640	640
	1040	520	1000
,, 1/60 ,, ,,	728	668	848
	848	668	1028

giving a mean of 826.

Six out of these twelve sub-samples give a range of variation from this mean of from – 19 to + 21 per cent.

Nine out of these twelve sub-samples give a range of variation from this mean of from – 23 to + 26 per cent.

The twelve sub-samples give a range of variation from this mean of from – 37 to + 55 per cent.

All these sub-samplings were carried out by the author who made the N 70 V analyses, and in addition he carried out a series of sub-samplings of a sample containing a known number of organisms. This sample included 1000 medium Calanoids, and was sub-sampled thirty-eight times by eight different methods. The numbers estimated as being in the sample are as follows, according to the sub-samples taken:

Fraction examined	Volume of pipette cc.	Volume of sample cc.	Estimated number of medium Calanoids in the sample					
1/20	2·5	50	880	1020	940	1020		
1/20	5·0	100	560	960	1400	880		
1/30	5·0	150	660	1110	1020	1110		
1/40	2·5	100	1060	1000	1480	760		
1/50	1·0	50	800	1450	1100	1200	800	1250
1/60	2·5	150	900	1260	720	960		
1/100	1·0	100	1500	600	1200	600	1200	1200
1/150	1·0	150	900	1200	1050	1650	300	750

50 per cent of the sub-samples show a range of variation from the actual number in the sample of from – 20 to + 20 per cent.

75 per cent of the sub-samples show a range of variation from the actual number in the sample of from – 28 to + 26 per cent.

90 per cent of the sub-samples show a range of variation from the actual number in the sample of from – 44 to + 45 per cent.

100 per cent of the sub-samples show a range of variation from the actual number in the sample of from – 75 to + 65 per cent.

The mean is 1012, a difference of 1 per cent of the number actually known to be there (1000). The mean variation is 22·4 per cent of the known number—or of 90 per cent of the sub-samples it is 16·3 per cent of the known number.

It is the possible range of variation which is important. We may discount 10 per cent of the sub-samples as being ones which we can fairly assume would in practice have been detected as being too high or too low when the pipette was used. Combining these results with those of the other two series of sub-samples we may conclude that in the majority of instances the error will not exceed 30 per cent, but occasionally the error may reach 45 per cent.

Calanus spp.

The same sample made up of a known number of organisms, which we have just referred to in the case of medium Calanoids, contained 1000 specimens of *Calanus*. The sample was sub-sampled forty-four times by eight different methods. The numbers estimated as being in the sample are as follows, according to the sub-samples taken:

Fraction examined	Volume of pipette cc.	Volume of sample cc.	Estimated number of *Calanus* in the sample					
1/20	2·5	50	1000	900	960	880		
1/20	5·0	100	1060	780	1300	920		
1/30	5·0	150	960	1050	810	870	900	1200
1/40	2·5	100	800	720	1120	720	600	800
1/50	1·0	50	950	950	850	750	900	1400
1/60	2·5	150	360	780	1440	480	960	840
1/100	1·0	100	500	600	900	800	400	1000
1/150	1·0	150	750	600	750	2250	1180	1950

50 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 20 to + 18 per cent.

75 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 28 to + 30 per cent.

90 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 52 to + 44 per cent.

100 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 64 to + 125 per cent.

Again we may say that exceptional cases (10 per cent of the sub-samples) would actually in practice be detected when taking the sub-sample and the pipette emptied and refilled. So that we may say that usually the error will not exceed 30 per cent, but at times may reach 50 per cent. Where there are only a small number of *Calanus* in the sample these would be picked out and counted separately.

The mean of these estimated numbers is 919, being lower than the actual number by 8 per cent. The mean variation from the known number is 28 per cent of the known number, or if we eliminate the exceptionally high and low estimations (10 per cent of the sub-samples) the mean variation is 17 per cent of the known number.

Rhincalanus gigas

This large Copepod usually occurred in the N 70 V net samples in small numbers when they were picked out and counted separately so that an error did not arise. But when it occurred in large numbers the sample would be sub-sampled by the stempel pipette. A sample known to contain 222 specimens was sub-sampled forty-eight times by eight different methods; i.e. six times by each method. The numbers estimated as being in the sample were as follows, according to the sub-samples taken:

Fraction examined	Volume of pipette cc.	Volume of sample cc.	Estimated number of *Rhincalanus* in the sample					
1/20	2·5	50	330	300	360	380	220	260
1/20	5·0	100	540	380	440	380	460	400
1/30	5·0	150	345	435	420	420	420	420
1/40	2·5	100	240	360	340	120	280	360
1/50	1·0	50	75	125	200	350	50	200
1/60	2·5	150	450	180	150	240	330	450
1/100	1·0	100	150	200	0	200	150	300
1/150	1·0	150	300	375	150	300	75	150

50 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 46 to + 49 per cent.

75 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 77 to + 71 per cent.

90 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 77 to + 98 per cent.

The total of the sub-samples show a range of variation from the actual number in the sample of from − 100 to + 143 per cent.

The error with this large species is seen to be great. The pipette generally takes more than a fair sample; the mean of the estimated numbers is 287, whereas the actual number was 222, an error of 29 per cent. The mean variation was 122, or 55 per cent of the actual number present. In actual practice, when it was necessary to use the pipette for this species, particular care was taken to see as far as possible that a fair proportion was taken up, so that the error would not be so great as represented in this test, nevertheless we must assume that the error was often as high as 50 or even 70 per cent.

Chaetognatha

These organisms, like *Rhincalanus*, are not adequately sampled by the pipette method, and were nearly always picked out and counted separately. But occasionally when there were a large number of small specimens they would be sampled by the pipette. A sample containing 184 specimens was sub-sampled forty-eight times by eight different methods, i.e. six times by each method. The numbers estimated as being in the sample were as follows, according to the sub-samples taken:

Fraction examined	Volume of pipette cc.	Volume of sample cc.	Estimated number of Chaetognatha in the sample					
1/20	2·5	50	220	200	240	180	310	200
1/20	5·0	100	200	180	180	160	240	340
1/30	5·0	150	315	195	210	270	90	300
1/40	2·5	100	320	320	160	160	260	600
1/50	1·0	50	275	525	275	250	200	250
1/60	2·5	150	120	270	150	360	240	240
1/100	1·0	100	100	500	200	400	250	250
1/150	1·0	150	375	75	225	75	75	300

50 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 16 to + 36 per cent.

75 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 59 to + 63 per cent.

90 per cent of the sub-samples show a range of variation from the actual number in the sample of from − 59 to + 96 per cent.

The total of the sub-samples show a range of variation from the actual number in the sample of from − 59 to + 226 per cent.

As in the case of *Rhincalanus* the pipette tends to take more than a fair sample. The mean of the estimated numbers is 246, whereas the actual number present was 184, an error of 33 per cent. The mean variation was 87, or 47 per cent of the actual number present. Again in actual practice, when it was necessary to use the pipette for those forms, particular care was taken to see that a fair proportion was taken up so that the error would not be as great as represented in this test. We must assume, however, that the error might be as high as 70 per cent. In considering the horizontal distribution of the Chaetognatha more attention is paid to the N 100 H results where the error due to the stempel pipette method did not arise.

Taking into account the errors just outlined together with those greater little-known errors in the field it is clear that the actual numbers estimated in the survey have a value which is no more than the most general approximation to the actual conditions if by "conditions" we mean, as we must, the simultaneous conditions existing at the different stations compared (unless, of course, we are considering changes in conditions due to definite changes in time). But this does not mean that they are of no value. Let us take some examples. Let us compare the estimated numbers of three species of Copepod, *Oithona frigida*, *Drepanopus pectinatus* and *Calanus propinquus*, at the stations on three different lines in the area: say the A line and the C line of the South Georgia survey, and the line between South Georgia and the Falkland Islands, which we will call the SG/FI line. The numbers at each station are expressed as numbers per 50 m. haul for the top 250 m.

Oithona frigida:—A line: 901 3064 2031 1339
C line: 1491 1844 2045 3368
SG/FI line: 3753 7211 1853 3524 793

Whilst the laboratory error is of the order 15–25 per cent, considering the errors in the field, demonstrated by the results at St. 41 above referred to, we are not justified in drawing any other conclusion than that they are fairly evenly distributed and occurring in numbers of two or three thousand per 50 m. haul.

Drepanopus pectinatus:—A line: 124 2563 8 65
C line: 2639 6 7 3
SG/FI line: 2 0 0 0 0

Here, where again the laboratory error does not exceed 25 per cent, in spite of possible errors in the field, we can at once discern big differences between different points in the area, differences which, as we shall see, have a definite meaning.

Calanus propinquus:—A line: 29 1 5 14
C line: 16 34 55 139
SG/FI line: 39 25 *820* *911* *1360*

Here whilst the laboratory error did not usually exceed 30 per cent, but might reach 50 per cent, the errors in the field will probably not allow us to distinguish between the majority of stations, but we can fairly record a marked difference between those in italics and the rest. It is this nature of difference that we are concerned with recording.

It may be asked why do we not express the estimated numbers in round figures if we cannot distinguish between 820 and 911 or between 39 and 25. For two reasons: firstly, any rounding of the figures is going to introduce a further possible and unnecessary error, and secondly, whilst the error in the field due to differences in time counts against the exact comparison of different stations, it does not so count against comparison of hauls at different levels at the same station where these hauls are taken immediately following one another. Here only the laboratory error is involved, and whilst we are again only interested in the big differences it is well not to increase unnecessarily the laboratory error by arbitrary rounding. As an example of such depth distribution let us take the SG/FI line for *Calanus propinquus* in greater detail, showing the number per 50 m. haul for the top 250 m., as sampled by the routine N 70 V nets taken at 250–100 m., 100–50 m. and 50–0 m. The depth distribution at the five stations would appear as follows:

50–0 m.	34	44	3526	1919	6530
100–50 ,,	16	50	548	951	6
250–100 ,,	59	7	9	561	88

Here, in spite of the laboratory error, we clearly see the nature of the important differences between different levels; but it is well not to increase that error further by arbitrary rounding. Again, if these reasons had not been good ones, having indicated the values to be placed upon the figures, we should have considered time too valuable to be spent in rounding them all simply to save us from the possible criticism that they appear ridiculous.

PART II. THE PHYTOPLANKTON

By A. C. Hardy, M.A.

INTRODUCTION

Our knowledge of the phytoplankton of the Antarctic began with the publication of the report by Castracane (1886) on the diatoms collected by the Challenger Expedition. The 'Challenger' had penetrated as far as 60° 40′ S in the Kerguelen sector in 1874. This knowledge was greatly extended by the reports of Karsten (1905), Van Heurck (1909) and Mangin (1915 and 1922) upon the collections made by the Valdivia, Belgica, Pourquoi Pas? and Scotia Expeditions respectively. These monographs have been extensively used in the examination and identification of the Discovery material. Laying the foundations of our knowledge, these works have been largely systematic in character; the present report, building on these foundations, aims at examining the phytoplankton from the ecological standpoint, and as far as possible linking its production with the hydrological data, and later, in Part V, with the distribution of the zooplankton and the whale fisheries.[1]

The routine method of collecting samples of the phytoplankton was that of hauling the N 50 V net[2] from a depth of 100 m. to the surface at a standard uniform speed of 1 m. per second. This net has 200 meshes to the linear inch. With the exception of some references to the N 70 V net samples, taken at some of the earlier stations where the N 50 V net was not used, all the results described in this section, except additional data regarding *Coscinodiscus*, have been obtained from the analysis of the N 50 V samples. The N 70 V net catches only a few of the larger species of diatoms, and only in the case of the large *Coscinodiscus bouvet* are the results of the two nets at all comparable.

As many species as possible have been identified in the time available, but since the object of the present survey is to provide a general picture of the plankton community and to show which species are important in its economy, *all* the rarer forms have not been specifically determined. This is particularly so in dealing with the species of *Peridinium*, which have at no time in the present survey been really important and which are difficult to identify on the squared slide during the process of analysis.

Mangin (1915) has already drawn attention to the small number of Peridinales in the Antarctic. "Peridinales", he writes, "in striking contrast with what has been found in the Arctic regions are very rare in the Antarctic....It is the diatoms above all which contribute to and give the Antarctic flora its special character."

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[1] Since this Part II on the phytoplankton was written, Mr T. J. Hart (1934) of the Discovery staff has completed a much more extensive survey of the phytoplankton of these regions embracing later surveys at South Georgia and the wider regions of the Weddell Sea, Bellingshausen Sea, and Bransfield Strait areas. The present report (Part II), the publication of which was delayed whilst work on Part V, correlating the phytoplankton with the zooplankton and whale fisheries, was completed, forms an introduction to this excellent and more extensive monograph by Hart.

[2] For a description of this net see p. 17.

The relative importance of the four groups of the phytoplankton met with in our survey may be judged from the comparison of the totals of their estimated numbers in our samples:

Diatomales	1,846,000,000
Protococcoideae (*Halosphaera viridis*)	84,000,000
Silicoflagellata (*Distephanus* spp.)	420,000
Dinoflagellata (*Peridinium*, *Dinophysis* and *Ceratium*)	283,000

It is seen that the Dinoflagellates form but 0·001 per cent of the total phytoplankton.

Before passing to a general discussion of the phytoplankton as a whole and its production in relation to hydrology, we will give an account of the occurrence of the different species. The estimated numbers of the commoner forms are shown in Appendix I, and those of the less common and rarer forms are recorded in the text. At the top of each column in the Appendix is also shown the fraction of the sample examined, so that the actual number of each organism observed, on which the estimated total is based, can be seen. In the text the figure in brackets following the estimated number shows the actual number observed. *In many of the instances where rarer forms are recorded it will be noted that the figures representing the estimated totals have only a most hypothetical value and can mean no more than an indication of their presence in small numbers in the sample.* Similarly, many samples must contain small numbers of rarer forms which have not been recorded because they have not been taken in the fraction of the sample examined. The commoner species often occurred in such large numbers that only a very small fraction of the sample could be examined.

The significance of the Phytoplankton numbers

Throughout the survey we are comparing the quantities of phytoplankton at different stations as measured by the 50 cm. diameter net hauled from 100 m. to the surface, and in the report, unless otherwise stated, the relative quantities of the different organisms are expressed as numbers per haul of 100 m. No attempt has been made to express these quantities as numbers per cubic metre of sea water for two reasons. Firstly, because it is felt that estimates per volume of water by a calculation of the filtration of the net must be widely out owing to the clogging of the meshes of the net in the heavier hauls, and, secondly, because the diatoms are so much more numerous in the upper part of the column of water sampled as compared with the lower part that an average figure of diatoms per cubic metre for the whole column would have quite an artificial meaning.

The column of water which would pass through the ring of the net if it was hauled vertically from 100 m. to the surface without the net being attached would be approximately 20 cubic metres. Thus we can say that the average number of diatoms per cubic metre in the sea per column sampled is not less than one-twentieth of the number given in the sample. Actually it would be very much more, because not all the water in the column will pass through the net, and the amount it will be more will vary according to the number of diatoms reducing the filtration. We are concerned in this survey, as already explained on p. 27, with only the really large differences in the numbers of organisms at different stations. In considering these differences we must always remember that when contrasting hauls where the organisms are very numerous with hauls where they are much less numerous, the actual ratio of the numbers in the sea at the contrasted stations will be greater even than the ratio shown by the comparison of numbers in the samples collected. The laboratory errors in the estimation of the numbers in the samples have already been discussed on pp. 26, 27, where the methods of analysis are described.

LIST OF PHYTOPLANKTON SPECIES

Those shown in **heavy type** were the more important in this survey.

DIATOMALES

Melosira hyalina, Karsten.
M. sphaerica, Karsten.
Coscinodiscus bouvet, Karsten.
C. centralis, Ehr.
C. concinnus, W.Sm.
C. curvatulus, Gran.
C. excentricus, Ehr.
C. horridus, Karsten.
C. kerguelenensis, Karsten.
C. lineatus, Ehr.
C. oculoides, Karsten.
C. oppositus, Karsten?.
C. quinquies-marcatus,[1] Karsten.
C. spiralis, Karsten.
C. sub-bulliens, Jorgensen?.
C. subtilis, Ehr.
C. stellaris, Roper.
Coscinodiscus spp.
Actinoptychus undulatus, Bail.
A. vulgaris, Schum.
Asteromphalus brookei, Bail.
A. challengerensis, Castr.
A. hookeri, Ehr.
A. parvulus, Karsten.
A. regularis, Karsten.
Asteromphalus sp.
Actinocyclus antarcticus, Karsten.
Stephanosira decussata, Karsten.
Thalassiosira antarctica, Karsten.
Dactyliosolen antarcticus, Castr.
D. laevis, Karsten.
Corethron valdiviae, Karsten.
Rhizosolenia alata, Brightw.
Rh. antarctica, Karsten.
Rh. bidens, Karsten.
Rh. chunii, Karsten.
Rhizosolenia curva, Karsten.
Rh. obtusa, Hensen.
Rh. polydactyla, Castr.
Rh. rhombus, Karsten.
Rh. simplex, Karsten.
Rh. shrubsolei, Cleve.
Rh. styliformis, Brightw.
Rh. truncata, Karsten.
Rhizosolenia sp.
Chaetoceros atlanticus, Cleve.
Ch. castracanei, Karsten.
Ch. criophilum, Castr.
Ch. cruciatus, Karsten.
Ch. curvatus, Castr.
Ch. dichaeta, Ehr.
  var. ***tenuicornis***, Mangin.
Ch. flexuosus, Mangin.
Ch. neglectus, Karsten.
Ch. radiculum, Castr.
Ch. schimperianus, Karsten.
Ch. socialis, Lauder.
Ch. tortissimus, Gran.
Biddulphia polymorpha, Mangin.
B. striata, Karsten.
Eucampia antarctica (Castr.), Mangin, types ***balaustium*** and ***mölleria***.
Fragilaria antarctica (Schwartz), Castr
Fragilaria sp.
Synedra spathulata, Schimper.
Thalassiothrix antarctica, Schimper.
Navicula oceanica, Karsten.
Gyrosigma (*Pleurosigma*) *directum*, Grunow.
Scoliopleura pelagica, Karsten.
Tropidoneis antarctica, Grunow.
Chunniella antarctica, Karsten.
Nitzschia seriata, Cleve.

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[1] May include more than one species.

DINOFLAGELLATA

Peridinium antarcticum, Schimper.
P. castaneiforme, Mangin?.
P. depressum, Bail.
P. elegans, Cl. (var. Karsten).
P. minutissimum, Mangin.
P. pentagonum, Gran?.
P. turbinatum, Mangin.
Peridinium spp.
Dinophysis ovum, Schütt.
D. tuberculata, Mangin.
Ceratium pentagonum, Gourret, f. *longisetum* and f. *grandis*.
C. gibberum, Gourret?.
C. tripos atlantica, f. *neglecta*, Ostenfeld (Paulsen).

PROTOCOCCOIDEAE

Halosphaera viridis, Schmitz.

CHRYSOMONADINEAE

Phaeocystis sp. See p. 64.

SILICOFLAGELLATA

Distephanus speculum (Ehr.), Haeckel.
Distephanus sp.

DISTRIBUTION

DIATOMACEA

Melosira.

The two species of *Melosira* met with have only been recorded at four stations and in very small numbers. *M. hyalina*, Karsten, was found at WS 34, 40 and 43, and *M. sphaerica*, Karsten, only at WS 43. It is of interest, however, that all were taken in a small area at the south end of South Georgia, in surface water of Weddell Sea origin. *M. sol* (Ehr.) Kuetz, which Mangin (1915) regards as a very characteristic Antarctic species, was not met with in the present survey.

Coscinodiscus.

Of the sixteen different species recorded, *Coscinodiscus bouvet*, Karsten, *C. kerguelenensis*, Karsten, *C. oppositus*, Karsten?, and *C. lineatus*, Erh., occurred in the largest numbers.

C. bouvet. This diatom was widely distributed round South Georgia—but occurred in larger numbers on the south and east than on the western side. It was not recorded between South Georgia and the Falkland Islands, nor from the N 70 V samples taken between Tristan da Cunha and South Georgia. It would appear to be a true Antarctic diatom. Its distribution and numbers as sampled by the N 50 V net are shown in Appendix I and Fig. 16. It was also taken in large numbers by the N 70 V net, the samples from which yielded interesting information regarding its vertical distribution. At many stations they showed that more were to be found at levels below a depth of 100 m. than above it; they appeared to be gradually sinking and dying—the remnants, no doubt, of a heavy crop which had previously existed in the upper layers. Mangin (1915) has already shown that this species is characteristic of the Antarctic spring, occurring in large numbers from October to December, but declining in December and January, and giving place to other species of *Coscinodiscus* and to *Corethron valdiviae*. It was all but absent in the five Sts. WS 110–114 taken in autumn, late May, on the C line; 400 (4) only being taken at St. WS 110. Our survey of December and January appears to show *Coscinodiscus bouvet* in the act of declining and sinking. The majority of them appear to die. It is interesting to speculate whether some of them remain alive, perhaps forming resting spores, and sink from the surface layers of water, which are moving northward, into the lower masses of water moving back towards the pole. This might explain how species can maintain their population in the south when they are continually being carried away from the pole in the surface layers. No such spores were seen, but a few cells were found to be living even below 1000 m. All those that were found in the top 100 m. appeared to possess chromatophores; but below this level the percentage of those containing chromatophores decreased as the depth

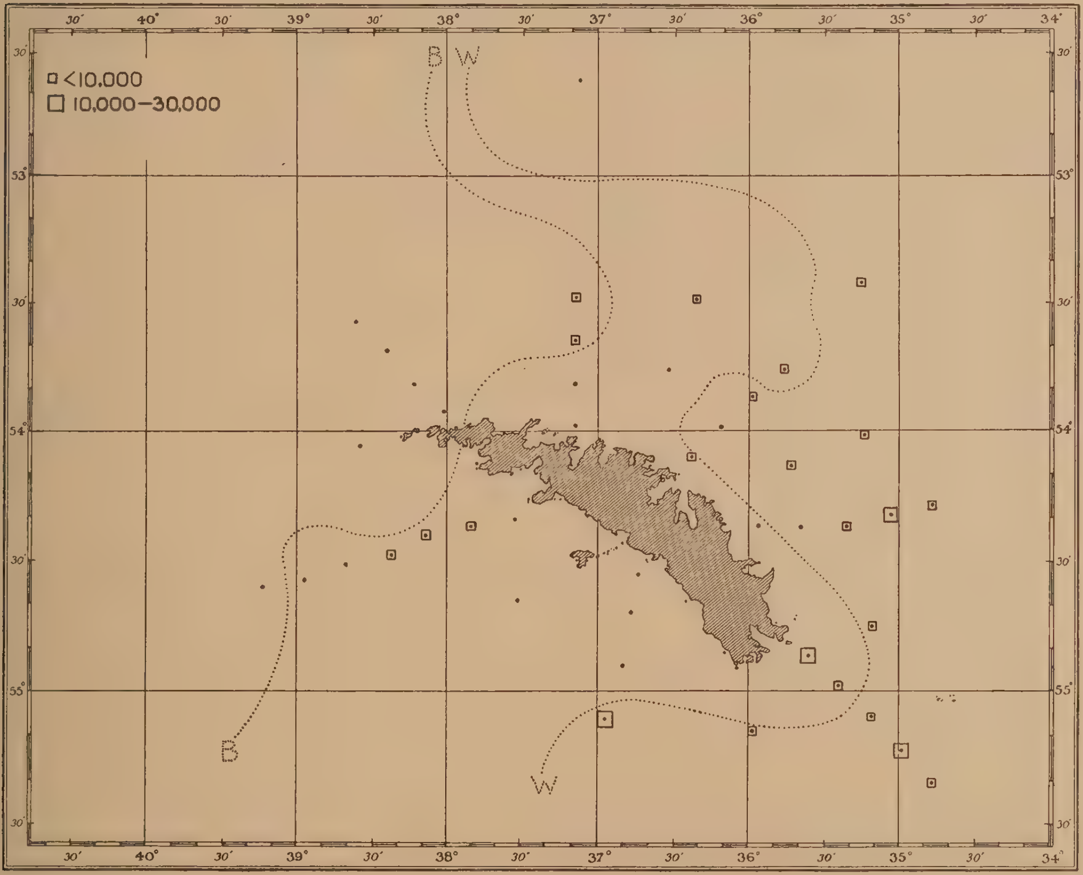


Fig. 16. Distribution of *Coscinodiscus bouvet* round South Georgia in the December–January 1926–7 survey. Scale of squares represents numbers per haul with N 50 V net from 100 m. to the surface. (See section on significance of plankton numbers, p. 40.) Negative observations shown as dots. The dotted lines *BB* and *WW* mark the probable boundaries of the surface waters from the Bellingshausen and Weddell Seas respectively, the zone in between being an area of mixing (cf. Fig. 6).

increased. The following percentages represent the average of analyses of the five stations: 129, 133, 137, 138 and WS 36:

250–100 m. depth: 69 per cent with chromatophores
500–250 ,, : 19 ,, ,, ,,
750–500 ,, : 4·5 ,, ,, ,,
1000–750 ,, : 0·5 ,, ,, ,,

In the single instance of a sample being taken from 2000–1000 m. (St. 138), as many as 28,000 were taken and only 1 per cent possessed chromatophores.

The depth distribution of *Coscinodiscus*, largely *C. bouvet*, as shown by N 70 V net samples at stations exceeding 100 m. in depth is shown in Table I. The months in which the stations were taken, November to February, are indicated at the head of each column.

Table I. *Depth distribution of* Coscinodiscus, *largely* C. bouvet, *as shown by N 70 V net samples at stations exceeding* 100 *m. in depth*

Month	December												Jan.	February	
Station	125	127	128	129	131	132	133	135	136	137	138	139	151	160	161
50–0	0	120	0	160	80	0	1,380	0	120	3,480	5,280	280	120	0	0
100–50	240	300	1008	2100	50	300	10,500	0	12	34,980	13,620	540	150	0	0
250–100	900	50 *a*	80 *b*	3000	150	180 *c*	2,580	450 *e*	1160	16,620	4,260	4200	520	60 *f*	0
500–250	1020	—	—	6680	—	—	200	—	—	8,940	5,150	—	1120	—	60
750–500	3060	—	—	3440	—	—	300	—	—	5,460	2,820	—	2520	—	180
1000–750	5840	—	—	1280	—	—	—	—	—	—	5,160	—	4800	—	40
2000–1000	—	—	—	—	—	—	—	—	—	—	28,080	—	—	—	—

Month	November			December									Jan.
Station	WS 20	WS 21	WS 22	WS 26	WS 29	WS 30	WS 33	WS 35	WS 36	WS 37	WS 38	WS 39	WS 40
50–0	3000	20	2760	4	8	100	180	2,760	100	204	0	4	180
100–50	720	2560	3640	120	40	40	480	16,320	1530	141	680	0	660
250–100	1080	650	7800	80	80	120	2400 *h*	10,680	6600	4200	12,720	720	1860 *j*
500–250	200	150	3000	1020	120	60	—	—	4620	1080 *i*	3,060	—	—
750–500	—	8	360	2100	40 *g*	60	—	—	2100	—	4,080	—	—
1000–750	—	—	1260	120	—	2	—	—	900	—	11,820	—	—

Month	January												
Station	WS 41	WS 42	WS 43	WS 44	WS 45	WS 46	WS 47	WS 48	WS 49	WS 50	WS 54	WS 61	WS 63
50–0	0	0	80	33	60	32	720	60	600	168	0	40	60
100–50	180	240	120	720	900	300	180	120	300	16	400	780	180
250–100	300 *k*	120 *l*	840 *m*	2400	480 *n*	36 *o*	20 *p*	180 *q*	80 *r*	60 *s*	1080	1250	180
500–250	—	—	—	1280	—	—	—	—	—	—	60	8340	780
750–500	—	—	—	480	—	—	—	—	—	—	—	1400	280
1000–750	—	—	—	—	—	—	—	—	—	—	—	3200	780

The footnotes refer to the ranges of depth of the lowest nets whenever shallow water prevented the standard range being obtained.

a = 150–110
b = 160–100
c = 170–125
e = 230–100
f = 180–100
g = 600–500
h = 130–100
i = 310–250
j = 175–100
k = 140–100
l = 170–100
m = 200–100
n = 170–100
o = 171–100
p = 150–100
q = 224–100
r = 225–100
s = 225–100

An examination of the N 70 V net results has in addition shown what appears to be a marked vertical migration of this species. By taking the percentage in which it occurs at different stations, and then taking the average percentages for those stations taken in daylight and those taken in hours of darkness in two series of shallow-water stations and deep-water stations, we see a marked difference between the distribution in the upper 250 m. in daylight and darkness. This is shown in Fig. 17. The figures are interesting. In the shallow-water stations (seven in daylight and four in darkness) we have the following proportions at different depths:

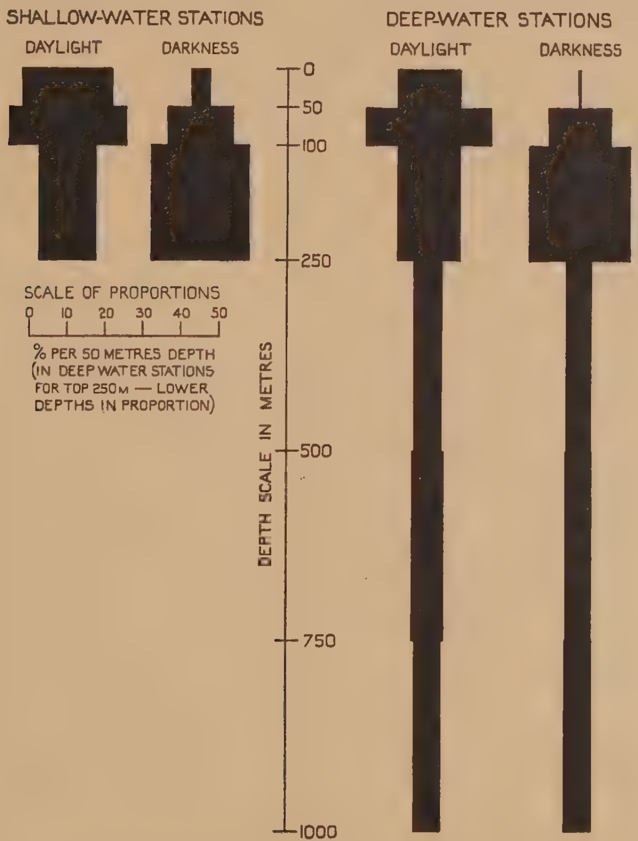


Fig. 17. Showing the average vertical distribution of *Coscinodiscus bouvet* at shallow- and deep-water stations taken in daylight and darkness and indicating an apparent diurnal vertical migration.

	Daylight	Darkness
m.	%	%
50–0	24	4·6
100–50	31	17·5
250–100	45	77·9

whereas in the deep-water stations (seven in daylight and seven in darkness) we have the following proportions:

	Daylight		Darkness	
m.	%		%	
50–0	7·7	45·9	0·4	46·4
100–50	15·3		8	
250–100	22·9		38	
500–250	17·8	54·1	17	53·6
750–500	19·4		18·2	
1000–750	16·9		18·4	

We see that in the deep-water stations the proportion above and below 250 m. is nearly the same in the two series for daylight and darkness. Taking the top 250 m. only, and expressing the proportions at different depths as percentages, we get figures that compare well with those for the shallow-water stations:

	Daylight	Darkness
m.	%	%
50–0	16·7	0·9
100–50	33·3	17·2
200–100	50	81·9

These figures have been used in the illustration for comparison with the shallow-water results and the proportions at the lower levels of the deep-water stations drawn to the same scale.

In the deep-water stations 39 per cent of the quantity present in the 250–100 m. layer during the night have passed up into the photic zone above during daylight. In the shallow-water stations the proportion is 42·3 per cent. Now we have already seen that approximately 30 per cent of the specimens in this 250–100 m. layer are dead—i.e. lack chromatophores—so that it would seem that another 30 per cent are either resting or moribund and no longer moving upwards during daylight. On comparing the proportions in the layers of 50–0 and 100–50 m. in daylight and darkness in each series it is seen that the distance up and down travelled by individual diatoms must be at least 50 m. each way.

If these figures are a true indication of a vertical migration, and it seems impossible to interpret them otherwise, it would appear that this is the first record of a diurnal vertical migration in the phytoplankton—a vertical migration which, it should be noted, is the opposite to that of the plankton animals, which rise towards the surface at night and sink in the daytime. Such an opposite vertical migration might have a distinct survival value for these plants. It is perhaps significant that it has been discovered for *Coscinodiscus*, a rounded form, which, if it is able to alter its specific gravity by the production of gas or gases within the envelope, would be able to rise bubble-like through the water.

C. centralis, Ehr., was only met with at two stations: WS 112, 6200 (62) and WS 114, 500 (5) on the C line at the end of May 1927.

C. concinnus, W.Sm. A single specimen of this typically northern diatom was met with at WS 31.

C. curvatulus, Gran, another northern form, common in Arctic seas, was recorded at eleven stations but never in large numbers. Its distribution is shown in Appendix I; it will be seen that it occurred on both sides of South Georgia.

C. excentricus, Ehr., was recorded in small numbers at four stations, all on the north-eastern side of the island: Sts. 126, 127, 136 and WS 27.

C. horridus, Karsten. Single specimens of this diatom were seen at two stations: WS 34 and WS 35.

C. kerguelenensis, Karsten, was recorded at fourteen stations but never in large numbers. Its distribution is shown in Appendix I.

C. lineatus, Ehr., was recorded in small numbers on each side of South Georgia. Its distribution is shown in Appendix I.

C. oculoides, Karsten, occurred in small numbers on each side of South Georgia; its distribution is shown in Appendix I.

C. oppositus, Karsten?. A diatom having a general distribution around South Georgia and at some stations taken in large numbers, was a form which we have provisionally regarded as a variety of *C. oppositus*; although very likely it should be regarded as a distinct species. Each cell possesses two apicules, one opposite or nearly opposite the other; but there is only one to each valve, i.e. that of one valve is placed at the opposite side of the disc to that of the other valve. In Karsten's *C. oppositus* each valve has two apicules, the ones of the upper and the lower valves lying one above the other and opposite or nearly opposite those of the other side. Thus in our specimens one apicule is absent from each valve. There is another important difference: the areoles are arranged not in a simple radial fashion but placed in narrow fasciculae giving an appearance not unlike that of *C. filiformis*, Karsten, although at times the fasciculae are so narrow as to give the appearance of an almost simple radial arrangement as described by Karsten for *C. oppositus*. The size of the cells and the form of the chromatophores of our specimens agree with his *C. oppositus*.

Whilst this diatom was common round South Georgia it was not found on the line between South Georgia and the Falkland Islands. Its distribution is shown in Appendix I.

C. quinquies-marcatus, Karsten. In the form as described by Karsten (1905) with five apicules, it was recorded in small numbers at the following stations: 161, WS 40, WS 67 and WS 68. At St. 44, a form was recorded having *six* apicules instead of five and forms with *seven* apicules were met with at the following stations: 160, WS 44, WS 45 and WS 67, whilst at the last-named station a single specimen having *eight* apicules was also recorded. Among the unidentified species of *Coscinodiscus* we have included one which agrees closely with *C. quinquies-marcatus* in both the sculpturing of the valves and their concave surfaces, but differs in lacking the apicules entirely. Since this species occurred at several stations with *C. quinquies-marcatus* and like it was confined to the western side of South Georgia, it may be that it is yet another form of the same diatom. Details of its occurrence are given under *Coscinodiscus* spp.

C. spiralis, Karsten, was recorded in small numbers at a single station: WS 34.

C. sub-bulliens, Jorgensen?. The specimens which we have queried under this name appear to agree with those of this species from the northern hemisphere except that they lack the two small apicules. They were taken on the western side of South Georgia in January and on the eastern side in late May 1927. Their numbers and distribution are shown in Appendix I.

Forms very similar to *C. sub-bulliens*, but lacking the spinulae as well as the two apicules, were noted and recorded amongst those unidentified.

C. subtilis, Ehr.: one specimen was recorded at St. 160.

C. stellaris, Roper: two specimens were recorded at WS 112.

Under *Coscinodiscus* spp. have been included examples of a diatom which bears a very close resemblance to *C. stellaris*, save that it has not the characteristic stellate marking of the species. These forms were taken in small numbers at the following stations as follows: WS 35, WS 36, WS 37, WS 39, WS 43 and WS 45.

Forms closely resembling *C. quinquies-marcatus* both in the sculpturing of the valves and their concave surfaces but lacking the apicules, were recorded at Sts. 160, WS 44, WS 45, WS 51, WS 63 and WS 70.

Other examples of the genus which were not specifically identified were taken as follows: WS 33, 200 (1); WS 41, 180 (3); WS 61, 100 (1); WS 63, 1200 (4); WS 110, 200 (1); WS 111, 600 (2); WS 112, 24,400 (244); WS 113, 2000 (10); WS 114, 27,000 (270).

Actinoptychus.

The two species recorded have only been taken in very small numbers: *A. undulatus*, Bail., at WS 63, WS 110 and WS 111, and *A. vulgaris*, Schum., at St. 125 and WS 112.

Asteromphalus.

Five different species were not infrequently met with, but only occurred in small numbers. The commonest were *A. brookei*, Bail., *A. hookeri*, Ehr., and *A. regularis*, Karsten: their distribution and numbers are shown in Appendix I.

A. challengerensis, Castr., occurred at the following stations: 133, 137, 138, WS 33, WS 34, WS 35, WS 36, WS 37 and WS 113.

A. parvulus, Karsten, at Sts. 137, 160, 161, WS 35, WS 40 and WS 45.

There also occurred forms which we have indicated as *Asteromphalus* sp., which was similar to *A. challengerensis* but with nine rays instead of eight; these occurred at Sts. 133, 134, 137, WS 33, WS 35 and WS 36. We are inclined to regard them as varieties of *A. challengerensis*; they occurred in six out of seven instances at stations at which *A. challengerensis* also occurred and in the seventh in close proximity to such stations. Still more significant, at St. 137 we found a form which was 8-rayed in one valve and 9-rayed in the other. *A. challengerensis* and the 9-rayed forms were all confined to water of Weddell Sea origin.

Actinocyclus antarcticus, Karsten.

This species was found only in very small numbers at the following stations: WS 34, WS 38, WS 67 and WS 110.

Stephanosira decussata, Karsten.

Found only at a single station: WS 50.

Thalassiosira antarctica, Karsten.

This species was recorded in small numbers (300) at one of the stations off South Georgia in March 1926: St. 30 in the N 70 V net, 100–50 m. It was most abundant on the C line, taken in November 1926, a month before the main December-January survey; on the November line the N 50 V net was unfortunately not used, and the following results are taken from the N 70 V net samples. It was found to occur at considerable depths—see Table II.

Table II

Depth m.	WS 18	WS 19	WS 20	WS 21	WS 22
50–0	2720	196,800	15,375,000	3,040	8560
100–50	360	17,136,000	3,552,000	2,140	1800
250–100	—	—	996,000	27,000	—
500–250	—	—	29,600	2,500	—
750–500	—	—	—	878	1600
1000–750	—	—	—	—	—

The numbers of this diatom on the C line in November must have been prodigious, clogging the meshes of the net. Normally this diatom passes through the meshes of the N 70 V net; for on only one occasion out of the ten on which it was taken by the N 50 V net was it also taken in the N 70 V net, and here only 660 are recorded against 19,200 taken in the N 50 V net. We can be certain that had the N 50 V net been used on this November C line the numbers of *Thalassiosira* recorded would have been very much higher.

A month later when this line was repeated in the December-January survey it had disappeared from this immediate region, although it occurred in moderate numbers to the south-east. Its distribution during this survey is shown in Appendix I and Fig. 18. It will be seen that it was more abundant in water of Weddell Sea origin.

Dactyliosolen.

Two species were recorded: *D. laevis*, Karsten, the distribution of which is shown in Appendix I, where it is seen to occur irregularly both in Weddell Sea water and in Bellingshausen Sea water; and *D. antarcticus*, Castr., which was only met with on the C line in late May 1927, in water of Weddell Sea origin, at the following stations: WS 110, 2300 (23); WS 112, 1100 (11); WS 113, 1700 (17) and WS 114, 1000 (10).

Corethron valdiviae, Karsten.

Mangin (1915) describes this diatom as the most important plant of the Antarctic plankton. Whilst it was all but absent in the stations taken in March 1926, being only taken at St. 23, it was taken at every station in the December-January survey of 1926–7, and at most of these stations in large numbers. It was particularly abundant on the north-east side of the island as shown in Fig. 19. Over ten million were taken at St. 124. In actual numbers it is third in importance in the survey. The first place is taken by *Chaetoceros socialis*, of which it was estimated that some 1500 million cells were taken in our samples, and the second place by *Nitzschia seriata* with a total of 211 million. *Chaetoceros socialis* and *Nitzschia seriata* are very small diatoms, the former occurring in dense swarms; and they were not so widely distributed as *Corethron valdiviae*. The total estimated number of *C. valdiviae* taken was nearly 24 million.

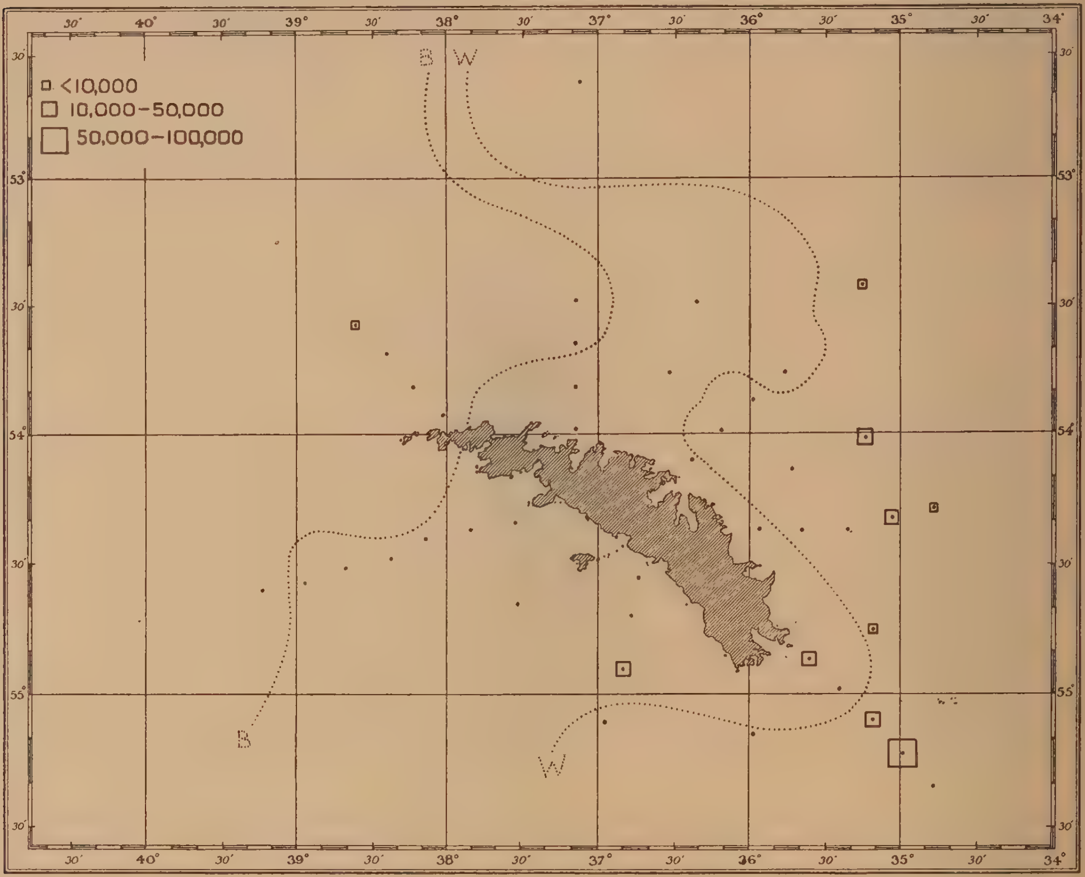


Fig. 18. Distribution of *Thalassiosira antarctica* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

Its abundance on the November C line cannot be judged from the N 70 V nets (the N 50 V nets not being used), since all but a few usually pass through their meshes. However, it may be mentioned that at St. 20 in this line 22,800 were recorded in the N 70 V nets (100–0), which is the second highest figure for *Corethron* occurring in the analyses of these nets. At Sts. 131 and 132, where the N 50 V nets gave 3,216,000 and 1,003,500 respectively, the N 70 V nets gave only 740 and 450. It would appear that this diatom was at any rate fairly abundant in November; but this is all we can say, since no true relation can be established between the N 70 V nets and the N 50 V nets in regard to this diatom on account of its usual passage through the meshes. It may well

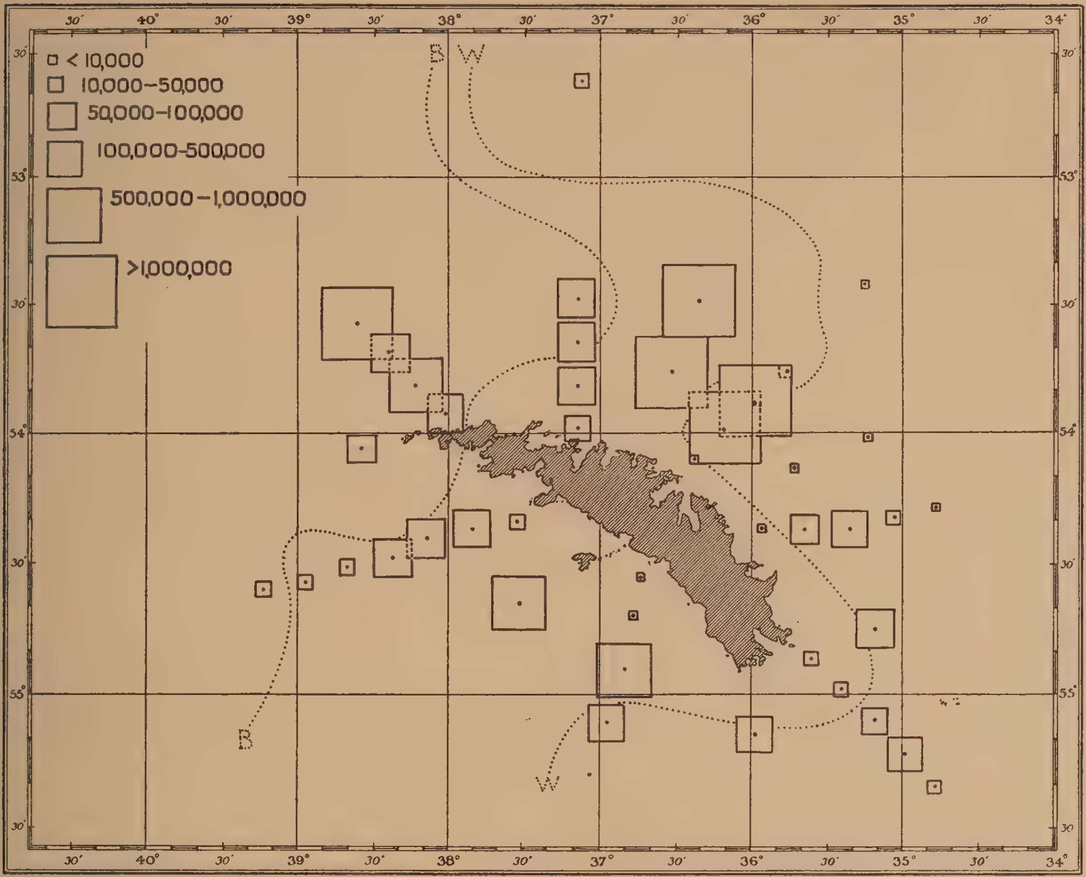

□ < 10,000
□ 10,000–50,000
□ 50,000–100,000
□ 100,000–500,000
□ 500,000–1,000,000
□ >1,000,000
B
W
40°
39°
38°
37°
36°
35°
34°
30′
53°
54°
55°

Fig. 19. Distribution of *Corethron valdiviae* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

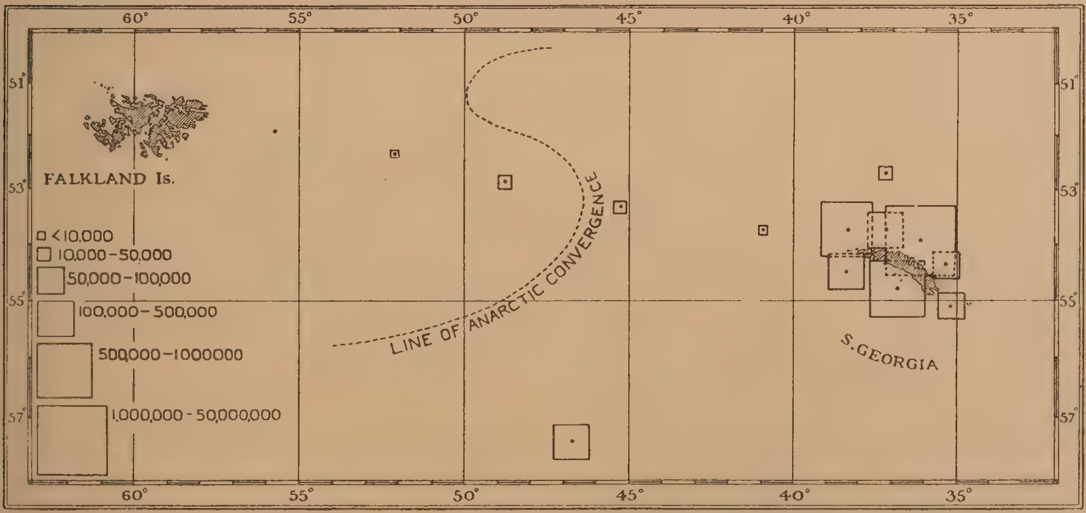

60°
55°
50°
45°
40°
35°
51°
53°
55°
57°
FALKLAND Is.
□ <10,000
□ 10,000–50,000
□ 50,000–100,000
□ 100,000–500,000
□ 500,000–1000000
□ 1,000,000–50,000,000
LINE OF ANARCTIC CONVERGENCE
S.GEORGIA

Fig. 20. Distribution of *Corethron valdiviae* at stations between South Georgia and the Falkland Islands, February 1927. The values shown at the seven points immediately around South Georgia represent average values for the stations on the seven radiating lines. Negative observations shown as dots.

be that the meshes of the N 70 V nets on the November line were considerably choked by the large number of *Thalassiosira* present in the catches.

It was present in smaller numbers between South Georgia and the Falkland Islands, and absent from St. 70 across the Antarctic Convergence; this is shown in Fig. 20. It was only present in comparatively small numbers on the autumn C line taken in late May—see Appendix I, Sts. WS 110–114. Mangin (1915) has shown that it dies down at the end of April and is very rare from May to October, its period of abundance being from December to April. In Appendix I its complete distribution as shown by N 50 V nets is given.

Karsten (1905) has distinguished from the typical *Corethron valdiviae* a more slender species under the name *C. inerme*. Mangin writes that the characters he (Karsten) has given it are so difficult to apply in the presence of slender forms of *C. valdiviae* that, except in a few particular instances, it is impossible to distinguish them. In our present survey all the forms appear to belong to *C. valdiviae*; but in the methods of analysis dealing with such enormous numbers it has been impossible to be certain that *C. inerme* has not been included amongst some of the slender forms of *C. valdiviae*.

Rhizosolenia.

Twelve species have been recorded.

Rh. alata, Brightw., has occurred on both sides of South Georgia; its distribution is shown in Appendix I. Since considerable confusion has arisen in the literature over this diatom and *Rh. obtusa*, Hensen, we have figured both from drawings made from specimens in the survey so that there can be no doubt as to the forms we mean by these names. *Rh. alata* is shown in Fig. 21. They were usually 30–35 μ in diameter, but more slender forms of 12 μ have not infrequently been taken and in a few instances forms as slender as 8 μ.

Rh. antarctica, Karsten, was only recorded at three stations on the western side of South Georgia: 161, WS 43 and WS 44.

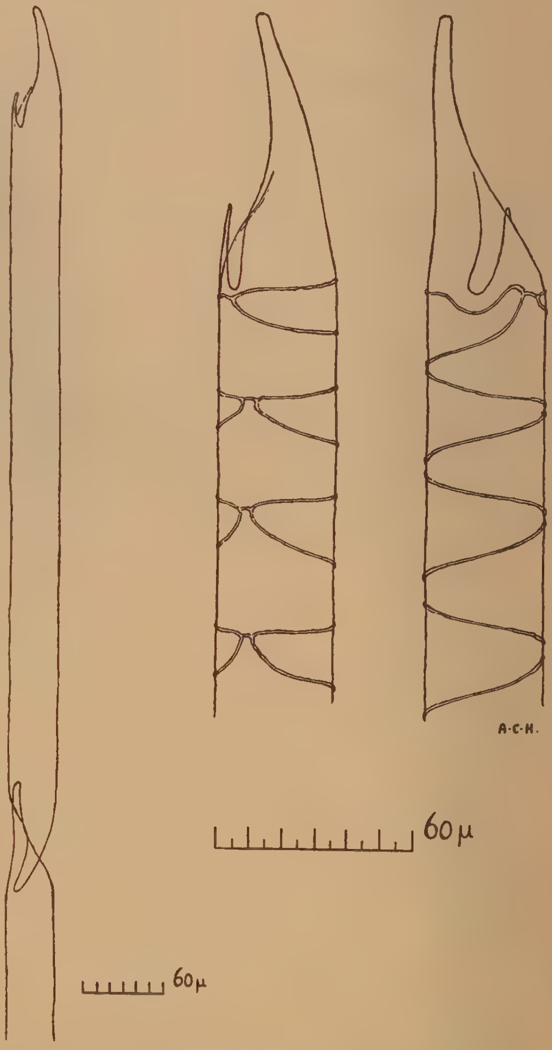


Fig. 21. *Rhizosolenia alata*, Brightw., drawn from specimens in the survey.

Rh. bidens, Karsten, was recorded at five stations: 137, 161, WS 112, WS 113 and WS 114.

Rh. chunii, Karsten, was only taken at two stations: 133 and 161.

Rh. curva, Karsten, occurred at twelve stations being taken in the largest numbers in the sub-Antarctic Zone between South Georgia and the Falkland Islands, as shown in Fig. 22. At Sts. 10, 11 and 12 approaching South Georgia from Tristan da Cunha in February 1926, where the N 50 V net was not used, it was taken in small numbers in the N 70 V net: 50, 45 and *ca.* 500 respectively. Its distribution as shown by N 50 V nets is given in Appendix I. The occurrence of this typically sub-Antarctic species in small numbers round South Georgia is interesting.

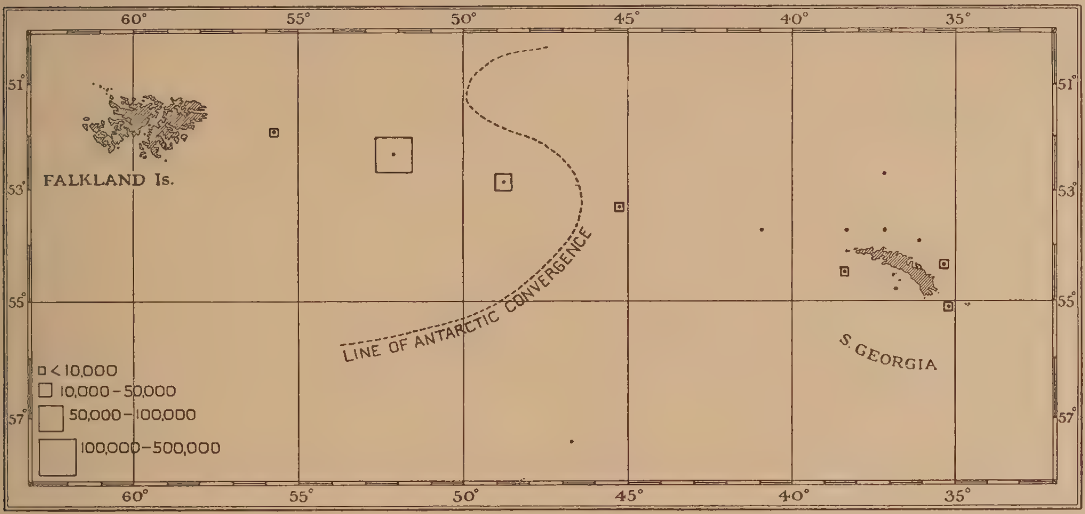


Fig. 22. Distribution of *Rhizosolenia curva* at stations between South Georgia and the Falkland Islands, February 1927. The values shown at the seven points immediately around South Georgia represent average values for the stations on the seven radiating lines. Negative observations shown as dots.

Rh. obtusa, Hensen, has occurred irregularly on each side of the island, being taken in largest numbers at St. 161. Its distribution is shown in Appendix I. Since, as in the case of *Rh. alata*, there has been confusion in the past over this species, we reproduce drawings in Fig. 23 made from specimens taken on the survey.

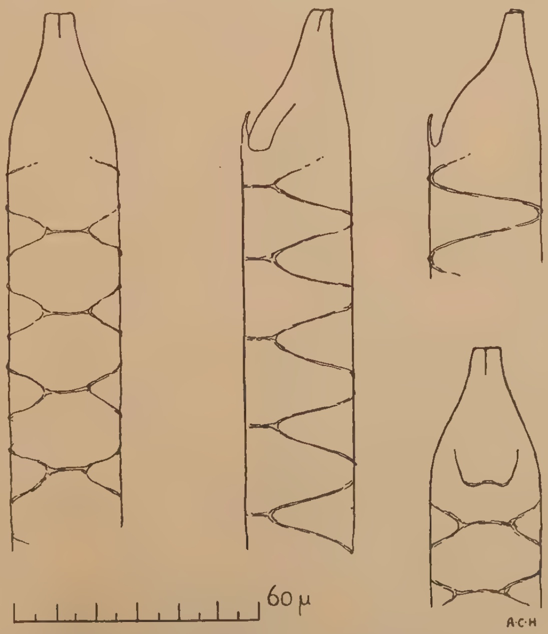


Fig. 23. *Rhizosolenia obtusa*, Hensen, drawn from specimens in the survey.

Rh. polydactyla, Castr. This diatom was not taken in any of the net samples, but was recorded in patches on a record of the Continuous Plankton Recorder between South Georgia and the Falkland Islands on April 20–21, from 51° 52′ S, 44° 29′ W to 51° 24′ S, 48° 32′ W.

Rh. rhombus, Karsten, was represented by a single specimen taken at St. 151.

Rh. simplex, Karsten, was taken in small numbers at twelve stations, mostly to the south and west of the island: 137, WS 33, WS 34, WS 35, WS 36, WS 39, WS 40, WS 43, WS 44, WS 45, WS 46 and WS 51.

Rh. shrubsolei, Cleve, was only taken at St. 161.

Rh. styliformis, Brightw. This species occurred at many stations. In November 1926 it occurred in the N 70 V nets (N 50 V nets not being used) at St. 19, 2520; St. 20, 6600; St. 21, 4 and St. 22, 340. Its distribution during the December-January, 1926–7 survey is shown in Fig. 24 and Appendix I, where it will be seen that it occurred in small numbers at many stations round the island and only at two outlying stations, one on each side of the island, in large numbers. 6,282,000 are recorded for St. 161 far to the south-west. It occurred in fair numbers between South Georgia and the Falkland Islands at St. 160 and WS 67–70, see Fig. 25, and was present in small numbers at Sts. WS 110–114 on the C line in late May 1927. The slender forms

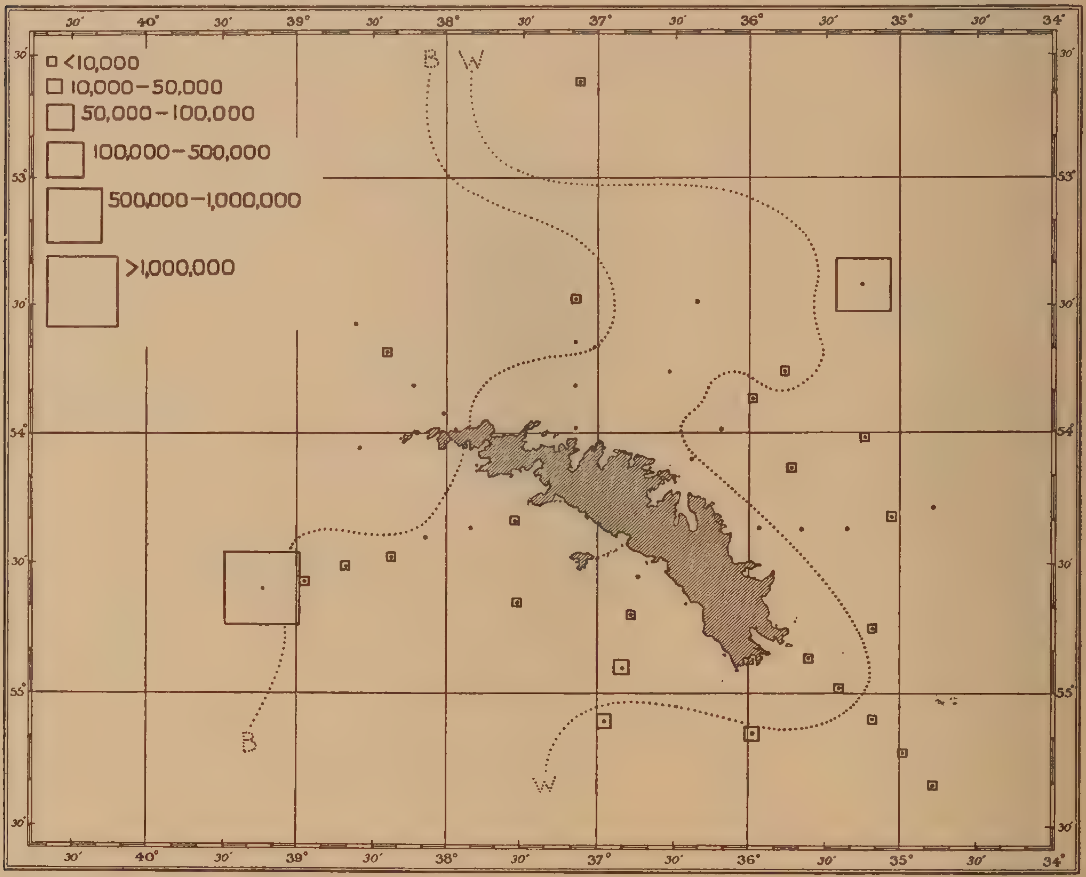


Fig. 24. Distribution of *Rhizosolenia styliformis* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

recorded by Mangin were present with the more typical stouter forms. Some forms bore the short spine typical of northern forms, others bore a much longer and more delicate spine which might incline one to believe that one was dealing with a separate species did one not often come across forms which bore a short spine at one end and a long delicate spine at the other.

Rh. truncata, Karsten, was taken in small numbers at three stations to the south-west of the island: WS 40, WS 44 and WS 45.

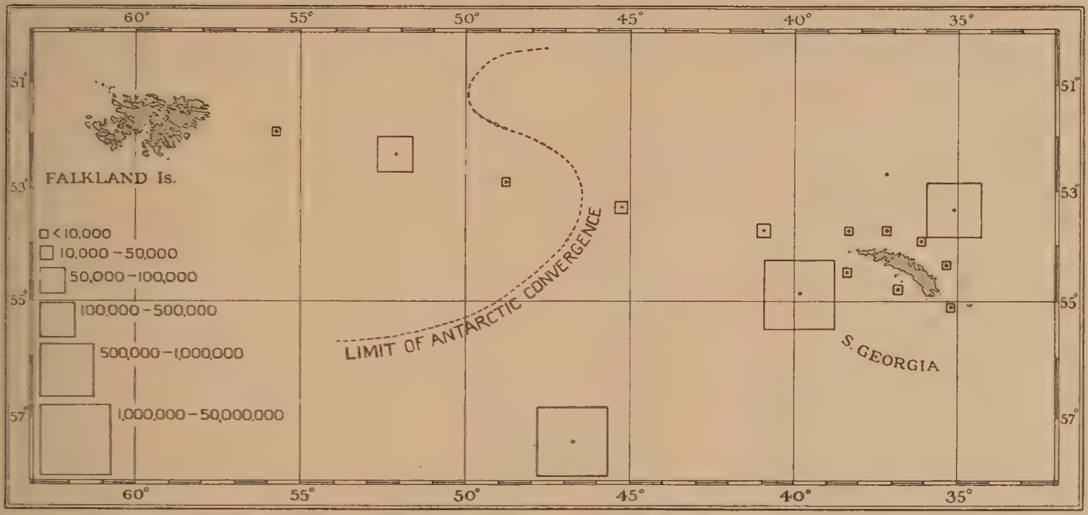


Fig. 25. Distribution of *Rhizosolenia styliformis* at stations between South Georgia and the Falkland Islands, February 1927. The values shown at the seven points immediately around South Georgia represent average values for the stations on the seven radiating lines. Negative observations shown as dots.

Chaetoceros.

Twelve species of this genus were recorded.

Ch. atlanticus, Cleve, was important at only a few stations: notably at St. 161 where over six million were taken. Its distribution is shown in Appendix I.

Ch. castracanei, Karsten, was also taken in large numbers at St. 161, 444,000 (74) and nearer South Georgia only on the eastern and southern side, i.e. in water of Weddell Sea origin: St. 137, 22,800 (38); St. 138, 600 (6); WS 34, 17,000 (17); WS 36, 5400 (18) and WS 37, 800 (4).

Ch. criophilum, Castr., was one of the more important diatoms in the survey occurring on all sides of the island. Its distribution is shown in Appendix I and Fig. 26. Mangin (1917) has shown that this species is quite distinct from *Ch. criophilum*, Gran, a northern diatom, which he has renamed *Ch. concavicornis*.

Ch. cruciatus, Karsten, was found at only two stations on the west side of the island: WS 40, 198,000 (33) and WS 44, 54,000 (9).

Ch. curvatus, Castr., occurred at fourteen stations and was distributed on both sides of the island: see Appendix I.

Ch. dichaeta, Ehr., and its variety *tenuicornis*, Mangin, have occurred irregularly on each side of the island; their distribution is shown in Appendix I.

Ch. flexuosus, Mangin, was found at the following stations: St. 137, 3000 (5); WS 40, 18,000 (3); WS 43, 96,000 (16); and WS 46, 300 (2).

Ch. neglectus, Karsten, was found at St. 133, 7200 (12); WS 38, 5600 (28); WS 44, 204,000 (38) and WS 63, 1200 (4).

Ch. radiculum, Castr., was found at St. 161, 54,000 (9); WS 40, 12,000 (2) and WS 43, 6000 (1). Mangin (1922) regards this species as a variety of *Ch. schimperianus*, Karsten.

Ch. schimperianus, Karsten, occurred most abundantly at the southern end of the island, but was also found at a few outlying stations on either side. Its distribution is shown in Appendix I and Fig. 27.

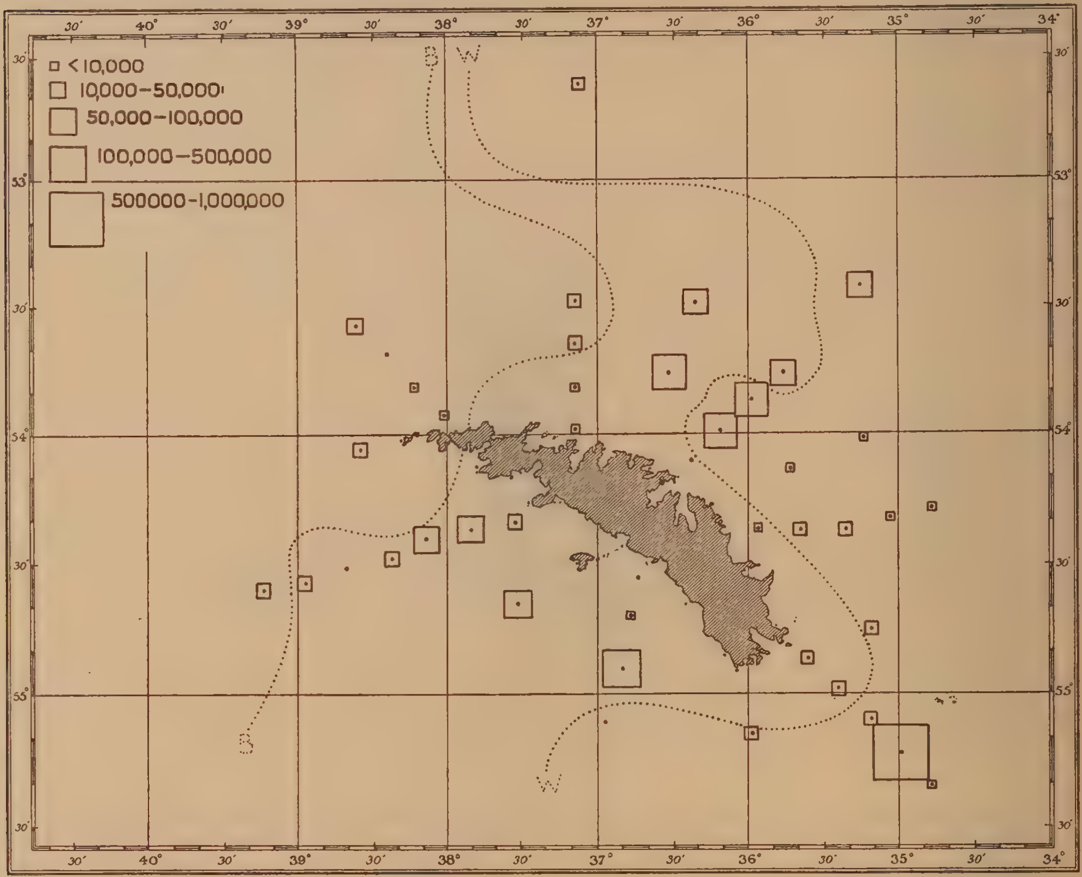


Fig. 26. Distribution of *Chaetoceros criophilum* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

Ch. socialis, Lauder. This species, which is so abundant at times in the northern hemisphere, is recorded by Mangin (1922) as being rare in the Antarctic, except for a limited area at the South Orkneys where it was abundant in December and January, 1903–4; Karsten did not record it at all. In our survey it proved to be the most important species, occurring in enormous numbers on both sides of the island, but particularly upon the western side where it formed a dense zone. Here at two stations over 500 million were recorded in single hauls from 100 m. to the surface; there can be no doubt that the numbers actually present in the columns of water must have been considerably greater—probably many times as great since the catching power of the net would be so much reduced by the clogging of the meshes. At no fewer than fourteen stations more than a million of the diatom were recorded. It is present in large numbers both in water of Weddell Sea origin and in Bellingshausen Sea water. Its distribution is shown in Appendix I and Fig. 28.

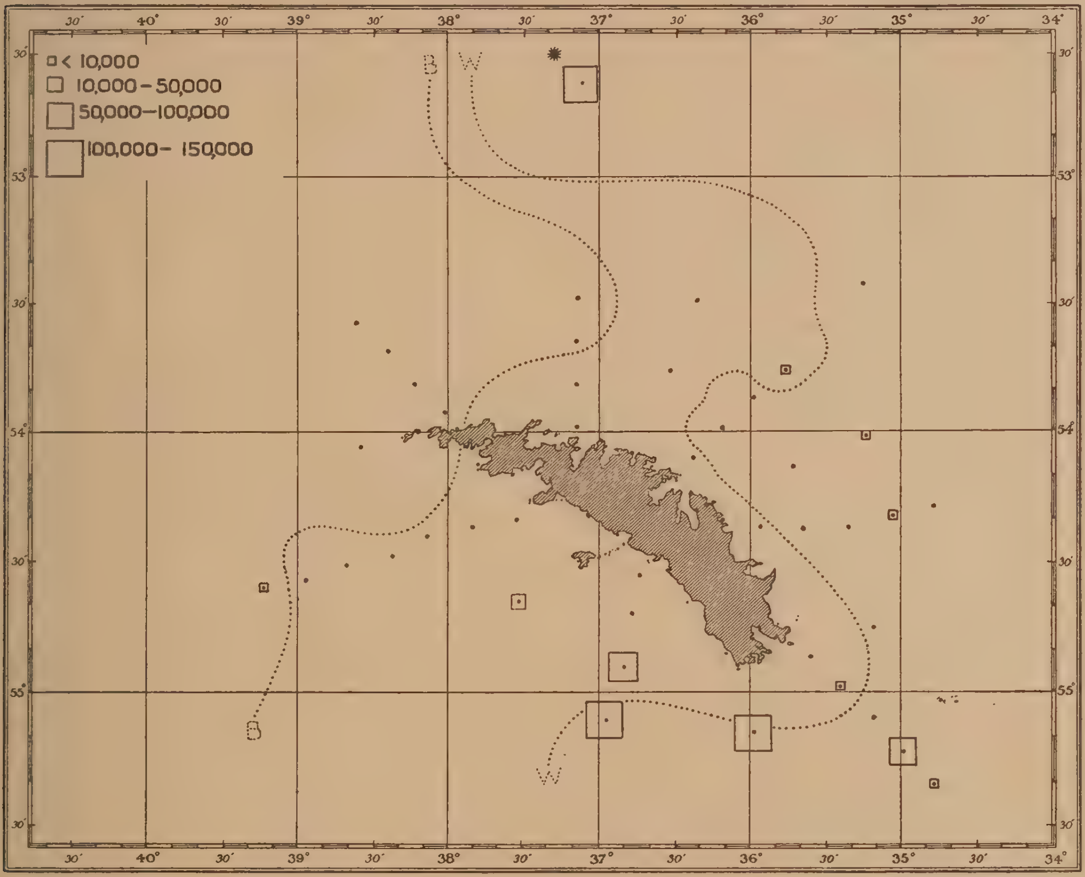


Fig. 27. Distribution of *Chaetoceros schimperianus* round South Georgia in the December–January 1926–7 survey. The square with an asterisk represents a value of 410,000. For full explanation see legend of Fig. 16.

Ch. tortissimus, Gran, was recorded in small numbers at only one station to the east of the island: WS 112.

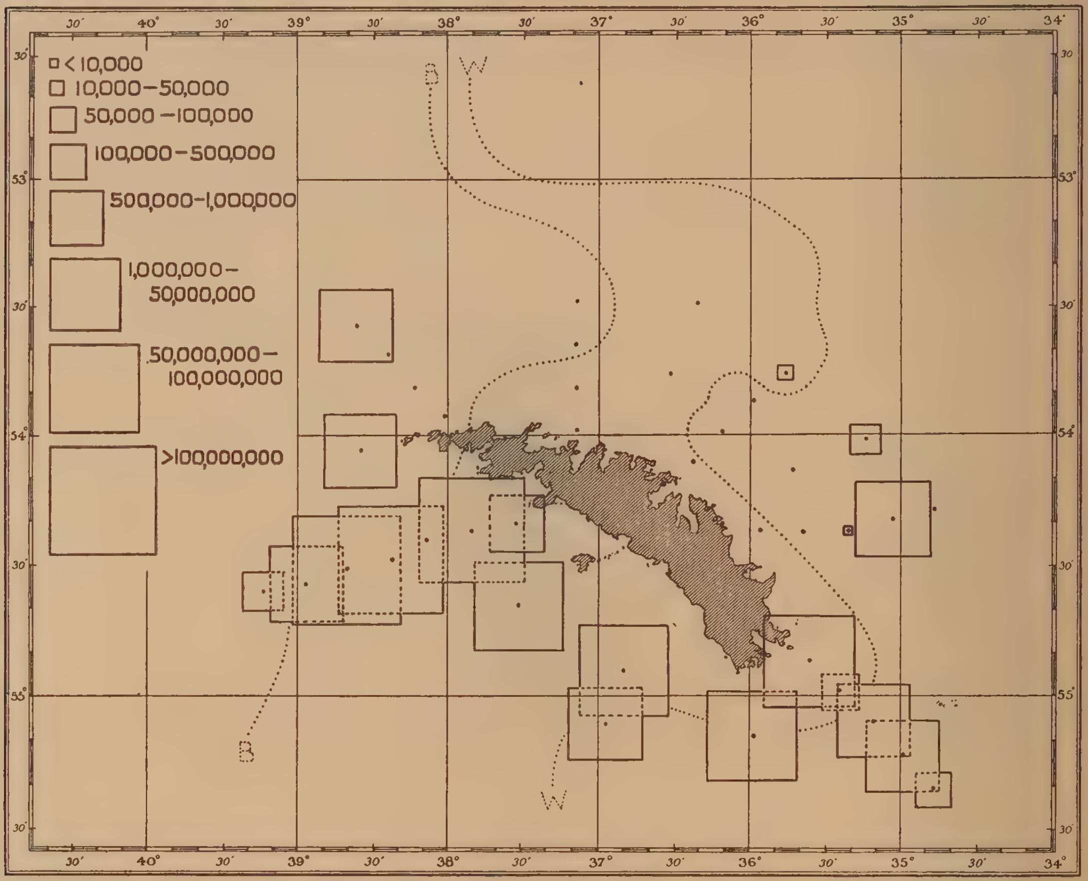
Biddulphia.

Two species were recorded. *B. striata*, Karsten, was found round South Georgia in the December-January survey in 1926–7 and was distributed both in water of Weddell Sea and Bellingshausen Sea. Its distribution and numbers are shown in Appendix I and Fig. 29.

B. polymorpha, Mangin, was only found at St. 161 in small numbers.

Eucampia (Mölleria).

Mangin has shown that the formation of a genus *Mölleria* by Castracane, as distinct from the genus *Eucampia*, Ehr., is not justified and has further shown by the discovery of intermediate forms and forms having the characters of both, that the two "species", *Eucampia balaustium*, Castr., and *Mölleria antarctica*, Castr., are really forms of one species which he names *Eucampia antarctica*. Following Mangin we will refer to the type *balaustium* and type *mölleria*; the former was found on each side of the island and the latter only at the southern end of the island. Their distribution and numbers are shown in Appendix I and Fig. 30.



□ < 10,000
□ 10,000–50,000
50,000 –100,000
100,000–500,000
500,000–1,000,000
1,000,000–50,000,000
50,000,000–100,000,000
>100,000,000
B
W
40°
39°
38°
37°
36°
35°
34°
30′
53°
54°
55°

Fig. 28. Distribution of *Chaetoceros socialis* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

Fragilaria.

F. antarctica, Castr., is one of the diatoms which occurred in considerable abundance. Its distribution and numbers are shown in Appendix I and Fig. 31. It will be seen to be absent from waters at the northern end of the island and most abundant where the two streams of Weddell Sea and Bellingshausen Sea waters meet at the south-west side of the island. 3,360,000 were estimated to be present at WS 44. It was also abundant (1,176,000) at St. 161 far to the south-west of the island. It was present in small numbers at Sts. 160, WS 67 and WS 68, between South Georgia and the Falkland Islands, extending just across the Antarctic Convergence. Small numbers were also taken on the C line in late May 1927. Another species of *Fragilaria* whose identity was not determined was noted in small numbers at WS 35.

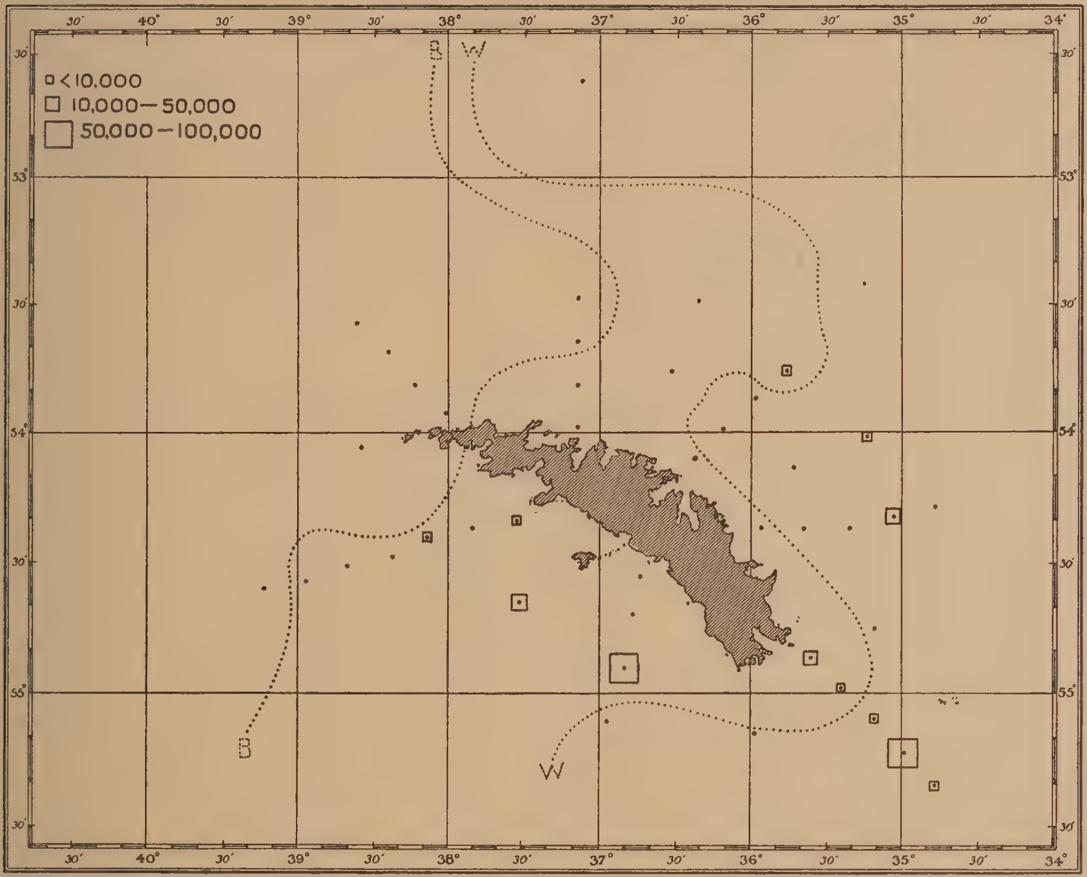


Fig. 29. Distribution of *Biddulphia striata* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

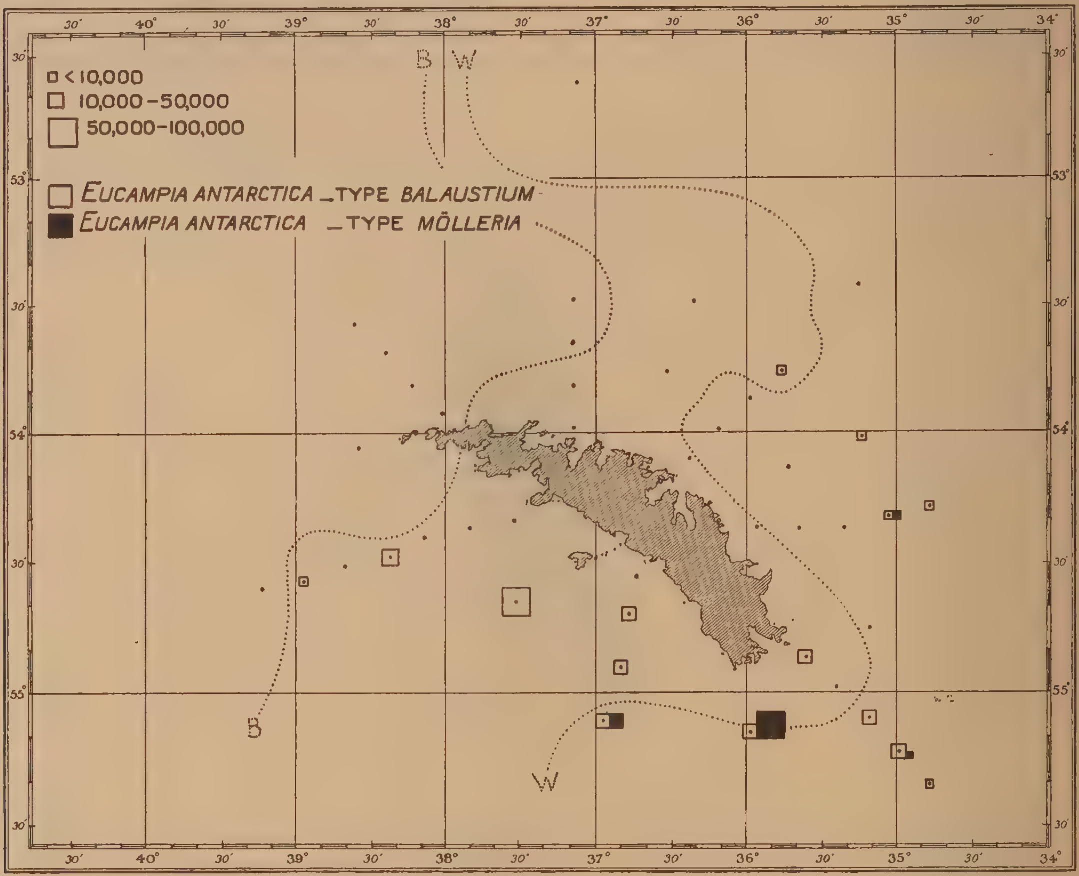
Synedra.

Synedra spathulata, Schimper, was met with at each side of the island but only in small numbers. It was taken at the following stations: WS 36, WS 38, WS 39, WS 43, WS 44, WS 45 and WS 51.

Thalassiothrix.

Thalassiothrix antarctica, Schimper, was abundant at St. 12 on the line approaching South Georgia from Tristan da Cunha in February 1926, where it was taken to the number of 4,600,000 in the N 70 V net used from 50 m. to the surface. Between this station and South Georgia the 'Discovery' passed through a dense zone of this diatom as revealed by the Continuous Plankton Recorder which was put into operation at

51° 57′ S, 32° 31′ W, and continued to record it in varying quantities for 78 miles, after which there followed 11 miles free of it and again followed another patch of 11 miles across and then another free region towards South Georgia. A graphic representation of this record is shown in Fig. 144. It was also met with at St. 41 in April nearer the island. In the December-January survey of 1926–7 it occurred in moderate abundance round the south end of the island in a somewhat similar distribution to that of *Fragilaria antarctica*. See Appendix I and Fig. 32.



□ < 10,000
□ 10,000–50,000
□ 50,000–100,000
□ EUCAMPIA ANTARCTICA _TYPE BALAUSTIUM
■ EUCAMPIA ANTARCTICA _TYPE MÖLLERIA
B
W
B
W
30′
40°
30′
39°
30′
38°
30′
37°
30′
36°
30′
35°
30′
34°
53°
54°
55°

Fig. 30. Distribution of *Eucampia antarctica* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

Navicula, etc.

Navicula oceanica, Karsten, was recorded at only two stations: WS 31, 3600 (2) and WS 45, 16,800 (7).

Gyrosigma (*Pleurosigma*) *directum*, Grun., has been found only on the south-western and southern side of the island in the region where the Weddell Sea and Bellingshausen Sea waters mix, and at St. 161 far to the south-west of the island. Its numbers and distribution are shown in Appendix I.

Scoliopleura pelagica, Karsten, was only recorded at two stations and in small numbers: WS 34 and WS 44.

Tropidoneis antarctica, Grun., was also only recorded in small numbers from two stations: 161 and WS 33.

Chunniella antarctica, Karsten. A single specimen of this species was recorded at St. 161.

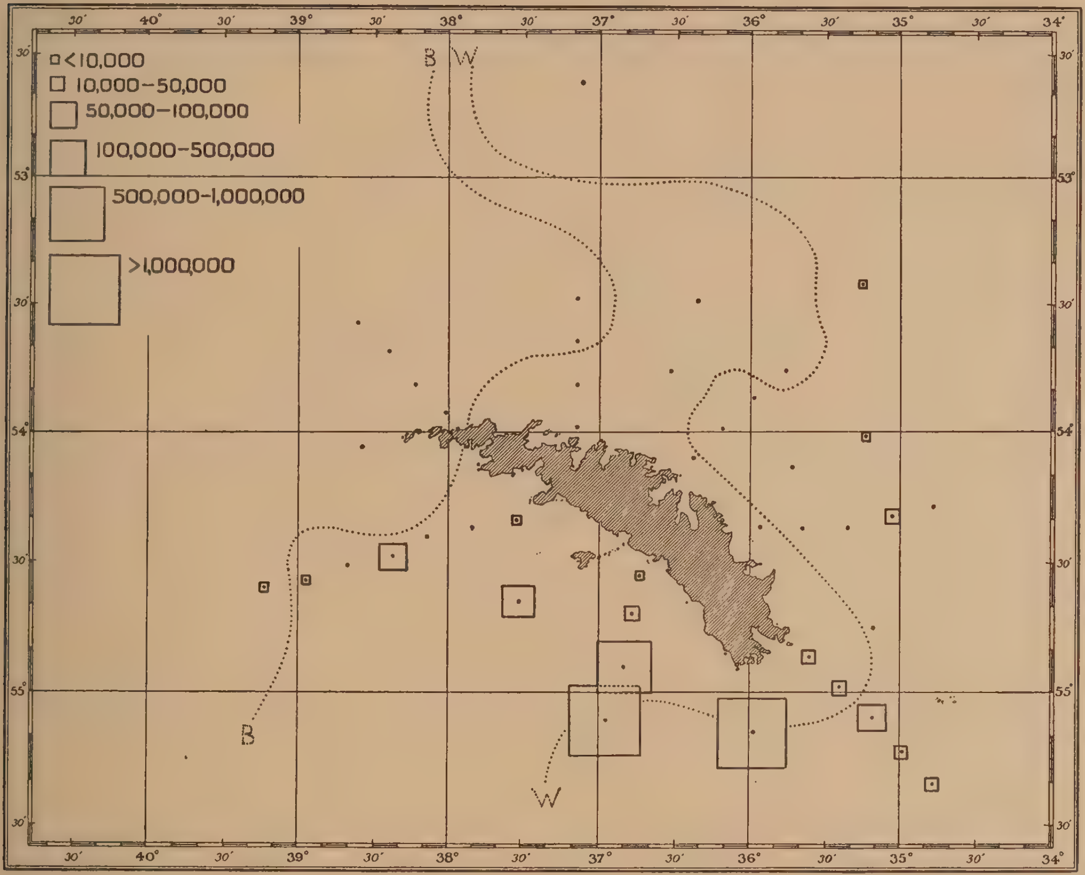


Fig. 31. Distribution of *Fragilaria antarctica* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

Nitzschia.

Nitzschia seriata, Cleve. This was one of the most abundant diatoms met with; the estimated number at WS 40 being 63,180,000. Its numbers and distribution are shown in Appendix I, and Fig. 33 shows its distribution during the December-January survey, 1926–7. It is seen to occur on both sides of the island but to be particularly abundant on the south-west side of the island where the waters of Weddell Sea and Bellingshausen Sea origin meet, and where the latter meets the continental shelf of South Georgia. It was present in small numbers in March 1926, at St. 23. It occurred to the westward of South Georgia in February 1927, being taken in large numbers at Sts. 160, 161 and WS 67, as shown in Fig. 34, but was not found beyond the Antarctic Convergence.

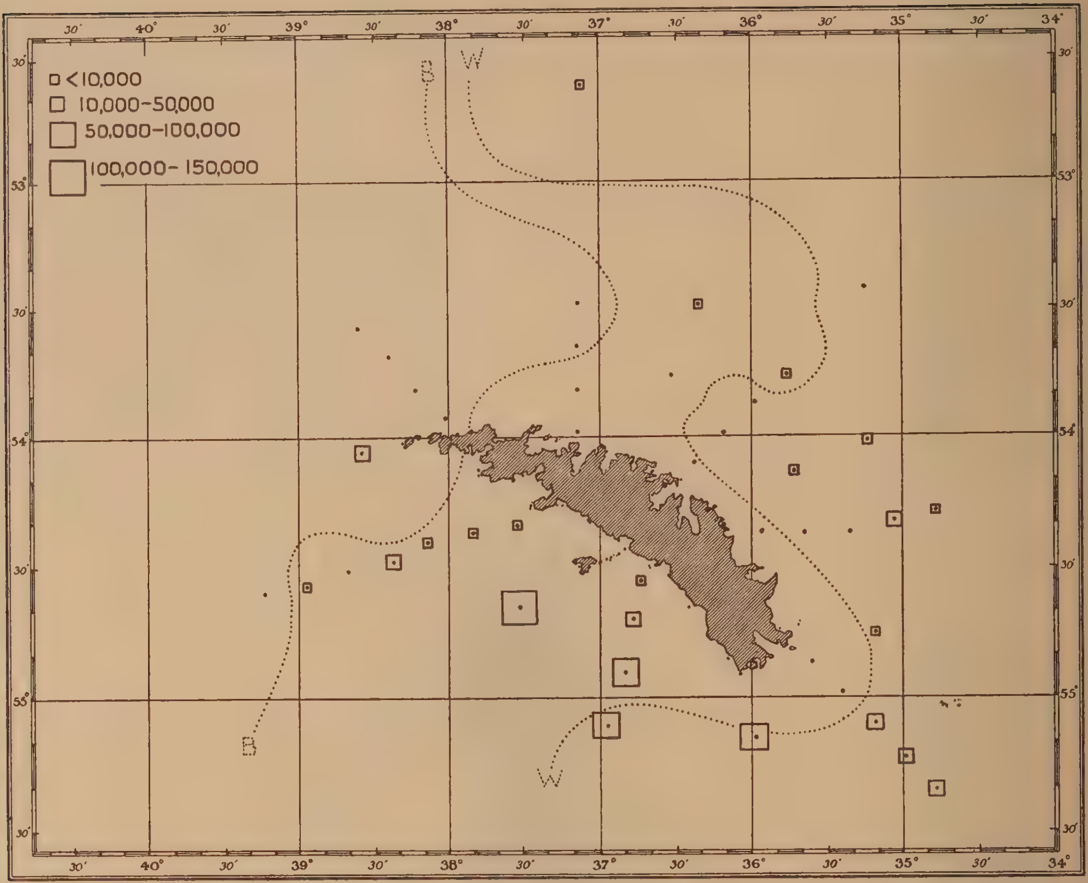


Fig. 32. Distribution of *Thalassiothrix antarctica* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

DINOFLAGELLATA

Peridinium.

As explained in the introduction to this section on the phytoplankton, the genus *Peridinium* has not been important in the present survey, and no attempt has been made in the time available to identify species in the routine process of analysis. Their total numbers are given in Appendix I. The following species have, however, been noted at the stations given after their names, but it must be understood that they are not limited to these stations:

P. antarcticum, Schimper: St. 161 and WS 41.
P. depressum, Bail.: WS 110, WS 112 and WS 113.
P. elegans, Cl. (var. Karsten): WS 67 and WS 69.
P. minutissimum, Mangin: WS 40.
P. turbinatum, Mangin: St. 161.
P. castaneiforme, Mangin?: St. 161.
P. pentagonum, Gran?: St. 41 C.

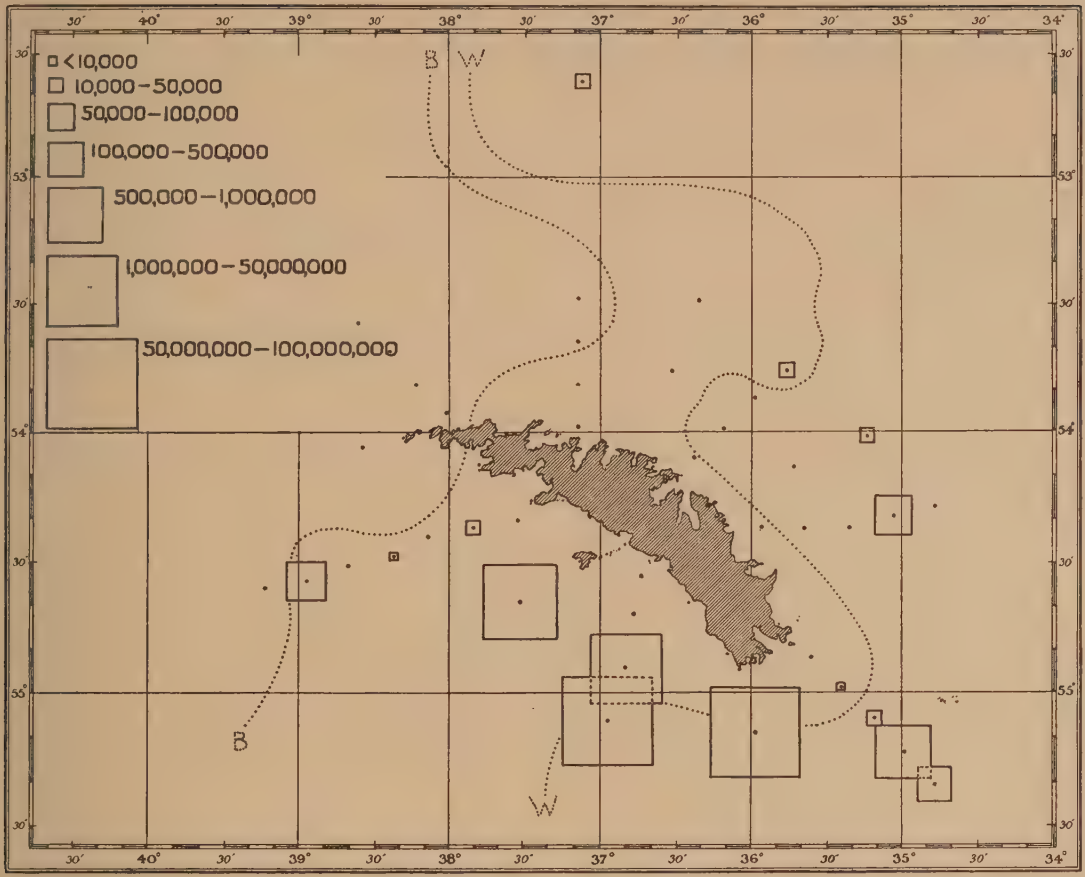

< 10,000
10,000–50,000
50,000–100,000
100,000–500,000
500,000–1,000,000
1,000,000–50,000,000
50,000,000–100,000,000
B
W
40°
39°
38°
37°
36°
35°
34°
53°
54°
55°
30′

Fig. 33. Distribution of *Nitzschia seriata* round South Georgia in the December–January 1926–7 survey. For full explanation see legend of Fig. 16.

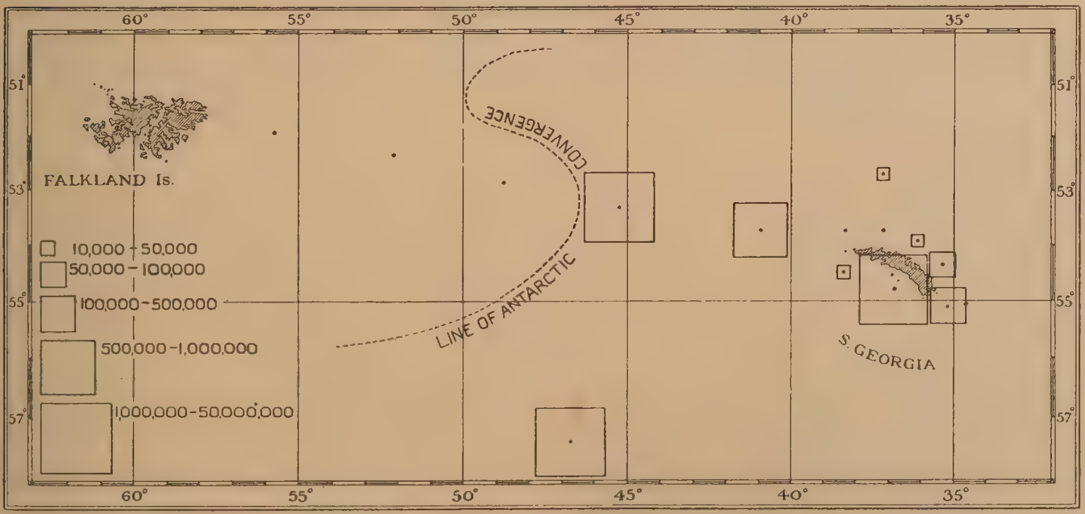

FALKLAND Is.
10,000–50,000
50,000–100,000
100,000–500,000
500,000–1,000,000
1,000,000–50,000,000
CONVERGENCE
LINE OF ANTARCTIC
S. GEORGIA
60°
55°
50°
45°
40°
35°
51°
53°
55°
57°

Fig. 34. Distribution of *Nitzschia seriata* at stations between South Georgia and the Falkland Islands, February 1927. The values shown at the seven points immediately around South Georgia represent average values for the stations on the seven radiating lines. Negative observations shown as dots.

Dinophysis.

Two species of *Dinophysis* have been met with but were not abundant: *D. ovum*, Schütt., at Sts. 133, WS 35, WS 36, WS 40 and WS 45, and *D. tuberculata*, Mangin, at WS 67.

Ceratium.

C. pentagonum, Gourret, was the only species of the genus met with in any numbers. The form *longisetum* was taken at odd stations on both sides of the island; but between South Georgia and the Falkland Islands, where this species was more abundant, the form *grandis* occurred in greater numbers, and at two stations, 68 and 70, apparently intermediate forms were taken. For their distribution, see Appendix I.

C. gibberum, Gourret?, a single specimen was taken at WS 70.

C. tripos atlantica, f. *neglecta*, Ostenfeld (Paulsen), was taken in small numbers at WS 110 in water of Weddell Sea origin.

PROTOCOCCOIDEAE

Halosphaera viridis, Schmitz, was only taken at three stations close to South Georgia, where it was particularly abundant; these stations lay adjacent to one another to the southward of the island: WS 40, 35,802,000 (5967); WS 43, 18,144,000 (3024) and WS 44, 28,800,000 (4800). It was also taken in smaller numbers at St. 161 far to the south-west of the island, 120,000 (20).

CHRYSOMONADINEAE

Whilst *Phaeocystis* was not taken in the region under consideration in the present survey, it may be of interest to note that it was taken in large quantities by the Continuous Plankton Recorder on November 13, 14, 19 and 20, 1926, in approximately the same latitude as South Georgia, but far to the eastward in the region of Bouvet Island; i.e. from 52° 29′ S, 9° 48′ E to 53° 37′ S, 7° 45½′ E and from 53° 06′ S, 1° 29′ W to 52° 47′ S, 2° 41′ W.

SILICOFLAGELLATA

Distephanus speculum (Ehr.) Haeckel, was recorded at a number of stations, particularly to the south and west of the island. Its distribution is shown in Appendix I. Another species of *Distephanus* was recorded at WS 45, but was not identified.

RELATIVE IMPORTANCE OF THE DIFFERENT ORGANISMS

In the introduction to this section on the phytoplankton, p. 40, reference has already been made to the relative importance of the four groups of phytoplankton. The diatoms are far and away the most important, being present in fifty-seven N 50 V samples to an estimated grand total of close on two thousand million.

We will now place the twenty more prominent species of diatoms, those occurring in numbers of more than a hundred thousand, in order of their relative numerical importance.

Chaetoceros socialis	1,493,000,000	*Chaetoceros dichaeta*	445,000
Nitzschia seriata	211,000,000	*Ch. schimperianus*	442,000
Corethron valdiviae	24,000,000	*Dactyliosolen laevis*	382,000
Fragilaria antarctica	10,000,000	*Biddulphia striata*	238,000
Rhizosolenia styliformis	9,800,000	*Chaetoceros curvatus*	214,000
Chaetoceros atlanticus	6,400,000	*Thalassiosira antarctica*	185,000
Ch. criophilum	6,200,000	*Rhizosolenia obtusa*	172,000
Thalassiothrix antarctica	518,000	*Rh. curva*	168,000
Coscinodiscus oppositus?	517,000	*Pleurosigma directum*	156,000
Eucampia antarctica	448,000	*Coscinodiscus bouvet*	114,000

This list is intended only for comparison with the results of future surveys. In other years, no doubt, other species will come into prominence and some of those here included will fade into insignificance. It must be realized also that this list does not represent the findings of a whole year, but mainly the results of December and January at South Georgia with the addition of stations in February between South Georgia and the Falkland Islands, and again, a few stations in March and late May on the eastern side of South Georgia. Had many samples been taken earlier in the spring there can be no doubt that *Coscinodiscus bouvet* and *Thalassiosira antarctica* would have been very much higher in the list. Again, had samples been taken in February 1926, when so much *Thalassiothrix antarctica* was taken by the Continuous Plankton Recorder on approaching South Georgia, this diatom would undoubtedly have held a more prominent position.

Next in importance to the diatoms as a whole comes *Halosphaera viridis* with a total of 83,866,000, which would place it before *Corethron valdiviae* in a list of prominence of all phytoplankton organisms. But, as already explained, we have found it exceedingly restricted in distribution.

Next comes the Silicoflagellate, *Distephanus speculum*, with a total of 418,000.

Lastly, the Dinoflagellates, with a total of 282,650 which may be subdivided as follows:

Peridinium spp.	233,200	*Ceratium pentagonum*	35,800
Dinophysis spp.	13,300	*Ceratium* spp.	350

COMPARISON OF THE PHYTOPLANKTON OF DIFFERENT REGIONS

Having described the distribution of the individual species, we may now discuss the phytoplankton as a whole in relation to the different regions and their water masses. A discussion of the actual hydrological conditions governing phytoplankton production will be reserved for a further section following the present one which is primarily topographical. We can divide the area under consideration into three parts: a region of the Southern Ocean to the north-east of South Georgia sampled at four stations (Sts. 9–12) on a voyage from Tristan da Cunha to South Georgia in February 1926;

the waters immediately surrounding South Georgia; and the region between South Georgia and the Falkland Islands.

Region north-east of South Georgia

At the four stations in this region: Sts. 9–12, taken in February 1926 (see Fig. 11), only the N 70 V nets were used. These were taken at the following depths: 50–0 m., 100–50 m., 250–100 m., and 500–250 m. The phytoplankton recorded is tabulated in Table III.

Table III

	9	10	11	12
50–0	—	50 *Rhizosolenia curva*	30 *Rhizosolenia curva*	2,000 *Rhizosolenia alata, obtusa* and *curva* 4,600,000 *Thalassiothrix antarctica*
100–50	—	—	15 *Rhizosolenia curva*	120 *Coscinodiscus sub-bulliens?*
250–100	—	—	—	—
500–250	—	—	40 *Coscinodiscus sub-bulliens?*	—

No information can be gathered as to the smaller species present. The main feature of interest is the mass of *Thalassiothrix antarctica* at St. 12. Between this station and South Georgia the Continuous Plankton Recorder revealed dense zones of this diatom; a graphic representation of this record is shown on p. 284.

The absence of the larger forms: *Coscinodiscus bouvet*, *Thalassiosira antarctica*, *Corethron valdiviae*, *Chaetoceros criophilum* and *Dactyliosolen* spp. is noteworthy, for, if present, some at any rate of the last four and all of the first named should have been taken by the N 70 V nets. The line of the Antarctic Convergence separating the waters of the Antarctic from the sub-Antarctic Zone lies between Sts. 10 and 11. The great production of *Thalassiothrix antarctica* at St. 12 contrasts with the poverty of phytoplankton towards and across the Convergence. A similar diminution in production is seen on the line between South Georgia and the Falkland Islands as the Convergence is approached and crossed; this will be presently described.

The waters surrounding South Georgia

We have seen that the waters in the immediate neighbourhood of South Georgia have been sampled as follows:

March, 1926, off the north-east coast,

November, 1926, off the north-east coast,

December-January, 1926–7, around the whole island, and May, 1927, off the north-east coast.

It will be convenient to discuss the distribution of the plankton in seasonal order—starting in the spring with the stations taken on the C line in November 1926, i.e. WS 18–22. The N 50 V nets unfortunately were not used on this line; but we can gain a slight knowledge of the larger forms of the phytoplankton present from the N 70 V nets, the analyses of which are tabulated in Table IV. The most important form present on the line as a whole is *Thalassiosira antarctica*; but at St. 20, in the middle of the line, a very dense and isolated patch of *Chaetoceros socialis* was recorded both from the 50–0 m. and 100–50 m. hauls. This diatom, whilst individually small, forms large masses of interlocking chains, and so is able to be caught by this net. The numbers given here, except for *Coscinodiscus bouvet*, which is fairly sampled by this net, are a mere indication that these diatoms are present in really much larger numbers. See note on *Thalassiosira antarctica*, on p. 49.

Table IV

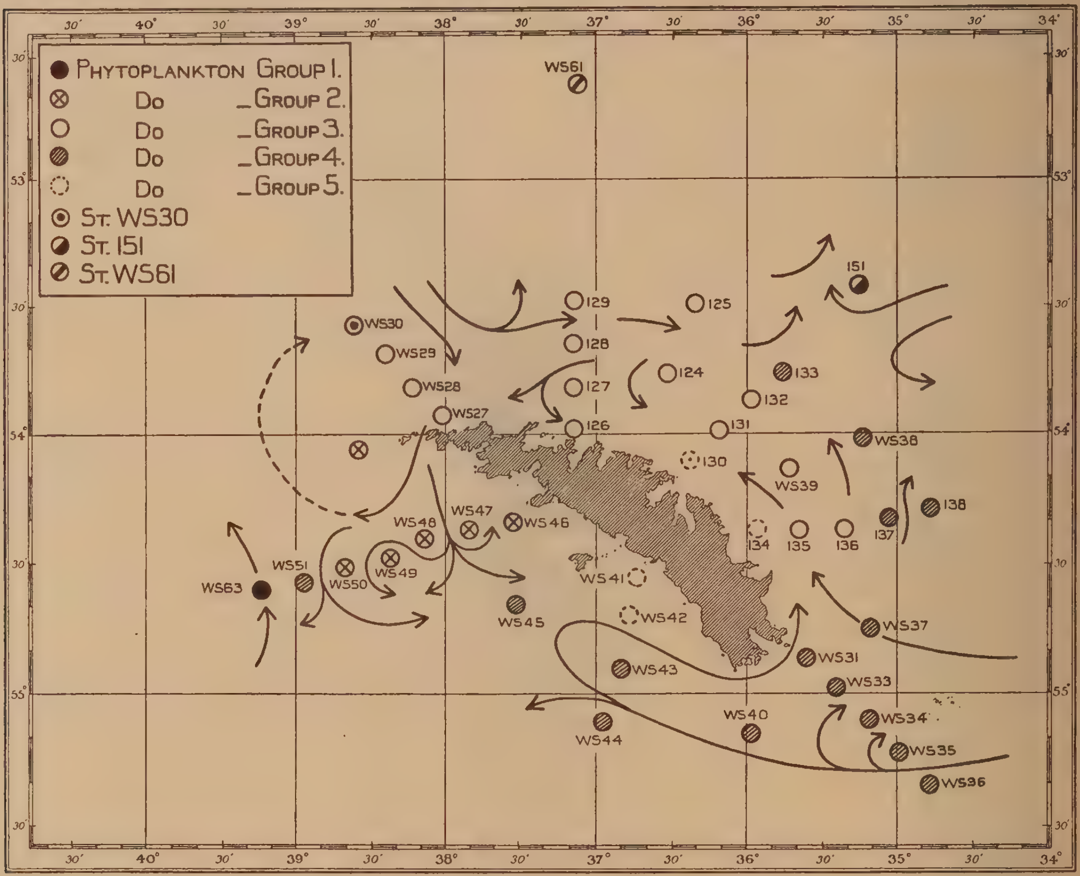
Distribution of phytoplankton as shown by N 70 V nets, Sts. WS 18–22.
November 26–30, 1926

Depth m.	Species	WS 18	WS 19	WS 20	WS 21	WS 22
50–0	*Chaetoceros criophilum*	—	17,208	22,200	48	400
	Ch. socialis	—	—	150,000,000	—	—
	Corethron valdiviae	—	1,440	22,200	4	—
	Coscinodiscus bouvet	480	2,040	3,000	20	2760
	Rhizosolenia styliformis	—	1,200	3,000	4	160
	Thalassiosira antarctica	2700	196,800	15,375,000	3,040	8560
100–50	*Ch. criophilum*	—	10,320	3,120	—	600
	Ch. socialis	—	—	500,000	—	—
	Cor. valdiviae	—	960	600	—	—
	Cos. bouvet	300	2,880	720	2,560	8640
	Rh. styliformis	—	5,040	360	—	120
	Th. antarctica	360	17,136,000	3,552,000	2,140	1800
250–100	*Ch. criophilum*			1,020	110	—
	Cor. valdiviae			60	—	—
	Cos. bouvet			1,080	650	7800
	Rh. styliformis			—	—	60
	Th. antarctica			996,000	27,000	—
500–250	*Ch. criophilum*			160	—	—
	Cor. valdiviae			120	—	—
	Cos. bouvet			200	150	3000
	Th. antarctica			29,600	2,500	—
750–500	*Cos. bouvet*				8	360
	Th. antarctica				888	1600
1000–750	*Cos. bouvet*				*	1260

* Sufficient depth for the haul, 1000–750 m., was only obtained at St. 22; the black line represents diagrammatically the sea bottom at the shallower stations.

Passing now to the main December-January 1926–7 survey, we are here dealing with samples obtained by the N 50 V nets, which give us a good picture of the phytoplankton present.

The totals of the phytoplankton cells taken at each station are charted in Fig. 38, in order to give an idea of the relative production in different parts of the area. It must, however, be remembered that we are dealing with diatoms of very different sizes—from the large *Coscinodiscus bouvet* to the small *Chaetoceros socialis* and *Nitzschia seriata*—and this fact must be borne in mind when forming a picture of relative production. Comparison of volumes of settled plankton are, however, also misleading, for the different types of diatom pack and settle so very differently: those with long spines such as *Chaetoceros* occupying much more space than compact rounded forms such as *Coscinodiscus*. In a preliminary description of the work of the expedition published in the *Geographical Journal*, the author (1928) gave a diagram illustrating the provisional results of this survey by showing the distribution of the phytoplankton round South Georgia as volumes; these were volumes measured on board at the time of the survey after the sample had been allowed to settle for some 24 hours. After these samples had been allowed to stand in their tubes for a very much longer period, a year or so, the



● Phytoplankton Group I.
⊗ Do _Group 2.
○ Do _Group 3.
▨ Do _Group 4.
◌ Do _Group 5.
⊙ St. WS30
◑ St. 151
⊘ St. WS61
30' 40° 30' 39° 30' 38° 30' 37° 30' 36° 30' 35° 30' 34°
30' 53° 30' 54° 30' 55° 30'
WS61
151
129
125
128
124
133
127
132
126
131
130
WS30
WS29
WS28
WS27
WS38
WS39
138
137
134 135 136
WS47
WS46
WS48
WS49
WS50
WS51
WS63
WS45
WS41
WS42
WS37
WS31
WS43
WS33
WS44
WS40
WS34
WS35
WS36

Fig. 35. Chart showing the stations in the South Georgia December–January 1926–7 survey distinguished according to their different phytoplankton floras. For further explanation see text.

volumes were nearly all considerably smaller and their relative proportions were considerably altered. The following examples will show how great can be the differences in the relative reductions in volume; such are largely due to species of different sizes and shapes predominating in the different samples.

Station	First volume cc.	Revised volume cc.
37	15·0	10·0
40	164·0	7·5
43	100·0	21·0
44	72·0	11·0
45	161·0	17·0

For comparison with Fig. 38 the phytoplankton production as measured by these revised volumes is shown in Fig. 40. The two methods of measuring show, when charted, patterns of general similarity, and a true idea of production probably lies between the two. A discussion of this production in relation to hydrology is reserved for the following section; here we will consider the grouping of the species in relation to the two currents of Bellingshausen Sea and Weddell Sea origin and their mixture.

We shall anticipate what will be discussed in the next section by noting that the two main areas of intense production lie in the areas of mixture of the two currents over the continental shelf on each side of the island. The charts of phytoplankton production should be compared with the water-movement chart in Fig. 6. Immediately inside the coast there is a belt of very poor phytoplankton production; this is in the area of poorly saline coastal water.

It is found that the results of phytoplankton analysis place the stations in certain groups defined by the principal contents of their samples. This grouping is shown in Fig. 35 where the water movements, slightly modified, are also shown (see later). We can recognize five distinct groups and then there are three stations, 151, WS 30 and WS 61, which do not fit with any particular group. The results of analysis have been tabulated in Appendix I in this arrangement of grouping, the stations being arranged topographically within each group. These tables should be referred to as the different groups are discussed.

Phytoplankton Group 1. This group is in water of definitely Bellingshausen Sea origin. It is represented in the December–January survey by only one station, WS 63, but with it may be grouped three stations to the west of South Georgia, 160, 161 and WS 67, which are also in Bellingshausen Sea water. In this group *Rhizosolenia styliformis*, *Chaetoceros atlanticus*, *Ch. criophilum*, *Fragilaria antarctica* and *Nitzschia seriata* may be abundant; *Corethron valdiviae* is present in moderate numbers, *Chaetoceros socialis* is present in very small numbers, and the following are absent: *Coscinodiscus bouvet*, *Thalassiosira antarctica*, *Biddulphia striata* and *Thalassiothrix antarctica*. These remarks refer only to the water sampled at this time and locality; we know that *Thalassiothrix antarctica* can occur in Bellingshausen Sea water, for it was taken in dense masses outside the South Shetland Islands in April 1927 (see Hardy (1928)).

Phytoplankton Group 2. This group comprises a series of stations to the west of South Georgia where Bellingshausen and Weddell Sea water are mixing over the continental shelf. The samples are characterized by very large quantities of the small diatom *Chaetoceros socialis*, which was all but absent in Group 1 of pure Bellingshausen Sea water, and by moderate quantities of *Corethron valdiviae* and *Chaetoceros criophilum*. *Rhizosolenia styliformis*, so abundant in Group 1, is here almost absent, whereas *Thalassiothrix antarctica* is present in small numbers but was absent in Group 1.

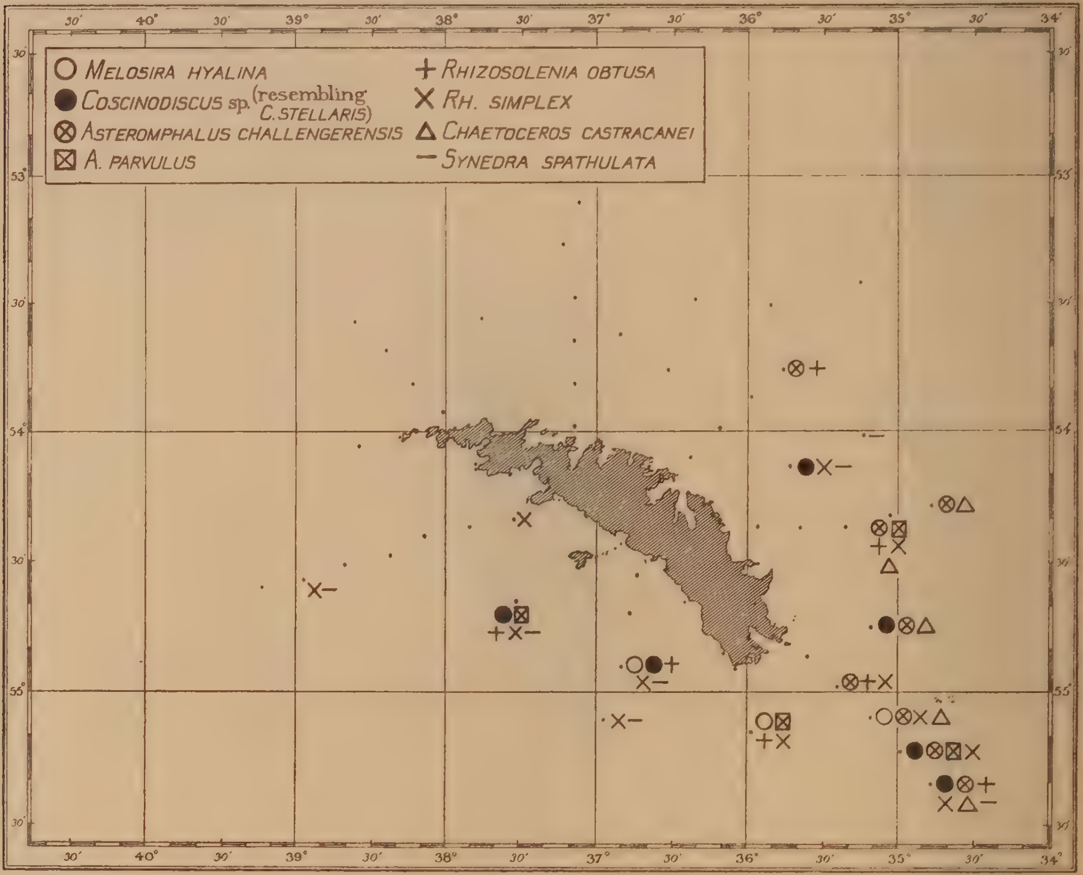

○ MELOSIRA HYALINA
● COSCINODISCUS sp. (resembling C. STELLARIS)
⊗ ASTEROMPHALUS CHALLENGERENSIS
⊠ A. PARVULUS
+ RHIZOSOLENIA OBTUSA
× RH. SIMPLEX
△ CHAETOCEROS CASTRACANEI
— SYNEDRA SPATHULATA
30′
40°
30′
39°
30′
38°
30′
37°
30′
36°
30′
35°
30′
34°
53°
30′
54°
30′
55°
30′

Fig. 36. Chart showing the distribution of a number of the less common species of diatoms confined to water of Weddell Sea origin.

Phytoplankton Group 3. This group represents a number of stations to the north and on the north-east side of South Georgia; it includes the area shown by Mr Clowes in his water-movement chart to be that of a mixing of the two currents, but also includes stations on the A line which should be Bellingshausen water and on the C and D lines which should be of Weddell Sea water. Yet, as will be seen on reference to Appendix I, all the stations in this group have a definite character as compared with other groups. This suggests that the area of mixture is greater than is indicated by some of the hydrological data, and it is actually supported by the temperature chart shown in Fig. 41. As in Group 2, *Chaetoceros criophilum* is present in moderate numbers and

Rhizosolenia styliformis almost absent, but it differs from Group 2 markedly in the much larger quantities of *Corethron valdiviae*, almost complete absence of *Chaetoceros socialis* and *Thalassiothrix antarctica*, and absence of *Fragilaria antarctica* and *Nitzschia seriata* (the last two were present in small numbers in Group 1 and large numbers in Group 2).

St. WS 30 combines the most outstanding character of Group 2 with that of Group 3 in having both large quantities of *Corethron valdiviae* and *Chaetoceros socialis*. It has also a moderate quantity of *Ch. criophilum*. According to the water movement chart this station should be in Bellingshausen Sea water, but Mr Clowes has indicated that there is a great swirl to the north-west of the island, and on consulting him he agrees that it is possible that some of the water from the area of Group 2 may have been detached and carried round in the swirl to St. WS 30. This is shown in the dotted line in Fig. 35, and would account for the presence of *Ch. socialis* in large quantities at this station.

Phytoplankton Group 4. The stations of this group lie in a patch to the south-east of the island in the track of the incoming Weddell Sea water; it is a patch which sends up arms on each side of the island in horseshoe shaped fashion. It is characterized by a large number of species which are absent or poorly represented in Groups 1, 2 and 3. See Appendix I. It has also large quantities of *Chaetoceros socialis*, *Fragilaria antarctica* and *Nitzschia seriata* and fair quantities of *Corethron valdiviae*, *Chaetoceros criophilum*, *Thalassiothrix antarctica* and *Eucampia antarctica*. There are in addition in this area small quantities of a number of species not tabulated in Appendix I. The distribution of these is shown in Fig. 36. There can be little doubt that this represents a homogeneous mass of water of Weddell Sea origin which penetrated in this survey farther up the west side of South Georgia than the hydrological data would lead one to believe. St. WS 51 appears to belong to, and has been included in, this group. On the eastern side too the water of this group does not fit exactly with the water movements based on hydrological data alone, but nearly so. In comparing Fig. 36 with Fig. 6 it is seen that in general the two sets of observations fit well together, but in detail perhaps the study of the plankton may be of assistance in filling in the picture.[1]

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[1] Since this section was written Hart's (1934) extensive study of the phytoplankton in these regions has appeared; it embraces later seasons at South Georgia and the Weddell Sea and Bellingshausen Sea areas. He refers to the recognition by Mr Dilwyn John, during the voyage of the 'Discovery II' in 1932, of two types of Weddell Sea surface water; these he calls "eastern" and "western" Weddell Sea water—see his p. 10 and Fig. 2. The "western" water is that which passes round the Weddell Sea (in a clockwise direction) nearest the continent, and emerges from its north-west corner; the "eastern" water is that which does not penetrate so far, but circulating inside the "western" water emerges to the east of it. Hart finds that these two types of water are characterized by different phytoplankton floras—see his p. 177. The "eastern" water is only moderately rich in species, but is very rich in quantity, the larger forms—*Chaetoceros criophilum*, *Rhizosolenia styliformis* and *Corethron valdiviae*—being strongly dominant. The "western" water is very rich in species with small forms dominant, particularly *Chaetoceros socialis*, *Thalassiosira antarctica*, and *Chaetoceros neglectus*, followed by *Fragilaria antarctica* and *Nitzschia seriata*. In his South Georgia survey of November 1930, in addition to the Bellingshausen Sea water he recognizes these two types of Weddell Sea water at South Georgia, the "western" Weddell water occurring to the south and south-west of the island, and the "eastern" Weddell water running up the north-east coast. It seems likely that in the phytoplankton of our 1926–7 survey the Groups 3 and 4, both from their position and character, may be identified with Hart's "eastern" and "western" Weddell Sea water respectively.

St. WS 61 and St. 151 lie farther out from the general region of the survey. Their phytoplankton is similar in type to Group 3, but the former has in addition a fair quantity of *Chaetoceros schimperianus* and the latter a large quantity of *Rhizosolenia styliformis*. As St. 151 is near the mixing of Weddell and Bellingshausen Sea waters, the *Rhizosolenia*, which is characteristic of Group 1, may have a Bellingshausen Sea origin, although it was present in moderate numbers in the Weddell Sea water of Group 4.

Phytoplankton Group 5. This group includes four stations, 130, 134, WS 41 and WS 42, with very little phytoplankton in the region of coastal water of low salinity. See Appendix I.

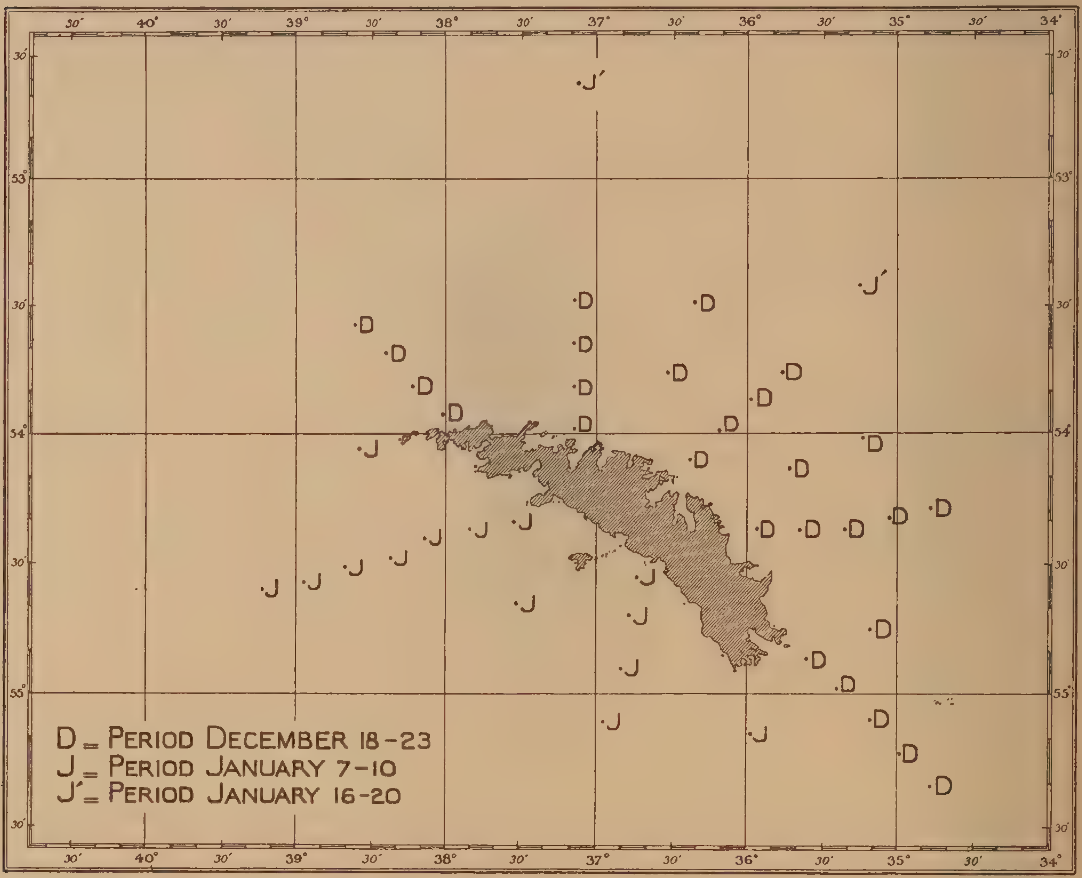

Fig. 37. Chart showing the time distribution of stations in the South Georgia plankton survey of December–January 1926–7.

One matter we must bear in mind when considering the results of the survey is that all the stations were not taken at the same time. They fall into two main separate periods as shown in Fig. 37. Those on the western side of the island were taken three weeks later than those on the eastern side—and the three outlying stations a week later again. We know what changes can take place in even so short a time. The C line in November (26th to 30th) was massed with *Thalassiosira antarctica*; yet on the same line in December (20th and 21st) there was not a single specimen of this diatom to be seen. The moral is obvious: stations in a plankton survey should all be taken as nearly together in time as possible. How difficult this ideal is to achieve is only realized by those who have attempted it in seas where violent storms limit work to infrequent intervals of comparatively short duration.

In March 1926, off the north-east coast of South Georgia, the phytoplankton was remarkably poor both in numbers and species. The analysis of the three N 50 V nets taken at this time is shown in Appendix I, Sts. 23, 31 and 41 C. Only five species are recorded. The N 70 V nets which were used at sixteen stations yielded no larger catches.

Table V

The phytoplankton between the Falkland Islands and South Georgia—together with that at St. 161 to the south-west of South Georgia

	WS 70	WS 69	WS 68		WS 67	160	161
Coscinodiscus lineatus	—	—	—		—	—	18,000
C. oppositus	—	—	—		—	200	12,000
C. quinquies-marcatus	—	—	200		500	400	18,000
Coscinodiscus spp.	300	—	—		500	200	—
Asteromphalus brookei	—	—	800	Antarctic Convergence	200	100	—
A. parvulus	—	—	—		—	100	—
A. regularis	—	—	—		900	100	—
Dactyliosolen laevis	—	—	3,200		1,600	800	198,000
Corethron valdiviae	—	8,800	10,200		16,700	1,900	216,000
Rhizosolenia alata	—	1,800	1,000		1,900	1,000	48,000
Rh. bidens	—	—	—		—	—	126,000
Rh. obtusa	—	—	—		1,100	4,600	108,000
Rh. curva	1200	136,000	27,800		1,300	—	—
Rh. styliformis	3000	107,600	2,400		30,600	22,500	6,282,000
Chaetoceros atlanticus	—	—	—		—	—	6,050,000
Ch. criophilum	—	—	400		800	—	3,864,000
Ch. castracanei	—	—	—		—	—	444,000
Ch. dichaeta	—	—	2,200		4,700	360,000	318,000
Ch. socialis	—	—	200		500	600	—
Ch. schimperianus	—	—	—		—	600	36,000
Eucampia antarctica f. *balaustium*	—	—	—		200	—	36,000
E. antarctica f. *mölleria*	—	—	—		—	—	12,000
Fragilaria antarctica	—	—	2,800		9,300	600	1,176,000
Gyrosigma directum	—	—	—		—	—	6,000
Nitzschia seriata	—	—	—		1,404,000	912,000	26,160,000
Peridinium spp.	—	—	200		600	100	48,000
Ceratium pentagonum f. *longisetum*	1050	200	1,000		2,800	—	—
C. pentagonum f. *grandis*	3030	9,600	8,000		600	—	—
C. pentagonum inter.	600	—	600		—	—	—
Halosphaera viridis	—	—	—		—	—	120,000
Distephanus speculum	—	—	—		—	—	103,000

Also taken at St. 161:

Asteromphalus parvulus	6,000	*Chaetoceros radiculum*	5,400
Rhizosolenia antarctica	48,000	*Biddulphia polymorpha*	6,000
Rh. chunii	12,000	*Tropidoneis antarctica*	18,000
Rh. shrubsolei	48,000	*Chunniella antarctica*	6,000

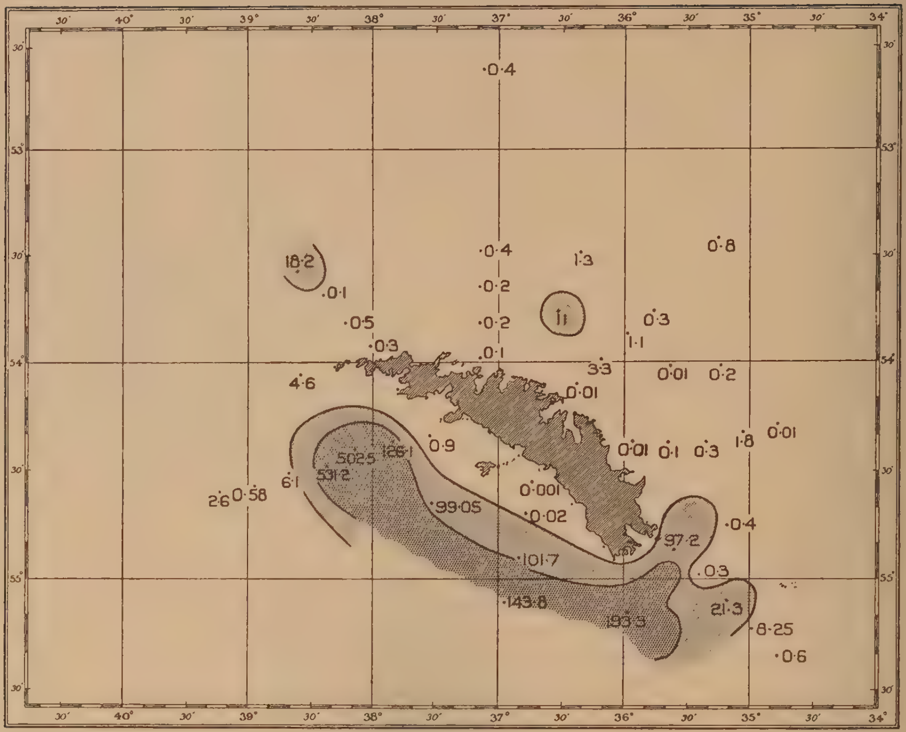
40°
39°
38°
37°
36°
35°
34°
53°
54°
55°
0·4
18·2
0·1
0·5
0·3
0·2
1·3
0·8
11
0·3
1·1
3·3
0·01
0·2
4·6
0·01
0·9
126·1
5025
531·2
6·1
2·6
0·58
0·001
0·1
1·8
0·4
99·05
0·02
97·2
101·7
0·3
143·8
193·3
21·3
8·25
0·6

Fig. 38. Contour chart showing the total quantity of phytoplankton in the South Georgia December–January 1926–7 survey measured as numbers of cells per haul with the N 50 V net from 100 m. to the surface. (See section on significance of phytoplankton numbers on p. 40.)

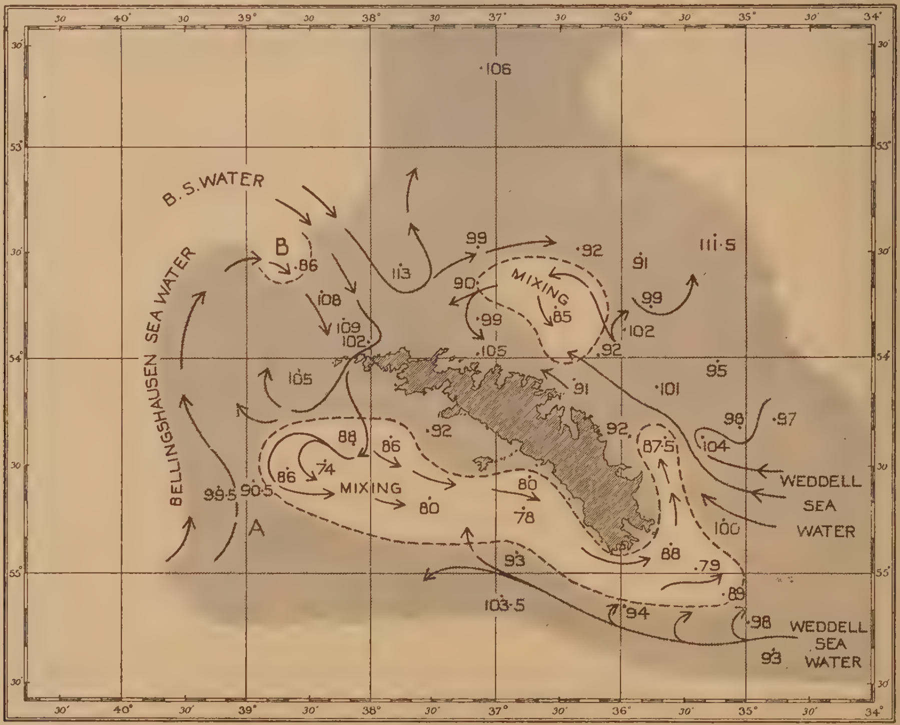
40°
39°
38°
37°
36°
35°
34°
53°
54°
55°
106
B. S. WATER
BELLINGSHAUSEN SEA WATER
B
86
113
99
92
91
111·5
90
MIXING
108
99
85
99
109
102
102
105
92
105
91
101
95
98
97
88
86
92
92
87·5
104
74
86
WEDDELL SEA WATER
99·5
90·5
MIXING
80
80
78
A
100
93
88
79
89
103·5
94
98
93
WEDDELL SEA WATER

Fig. 39. Chart showing the average phosphate content from 50 m. to the surface at stations in the South Georgia December–January 1926–7 plankton survey expressed as mg. per cu.m. Areas of values above 90 mg. per cu.m. are shaded. The main surface water movements are shown by arrows (cf. Fig. 6).

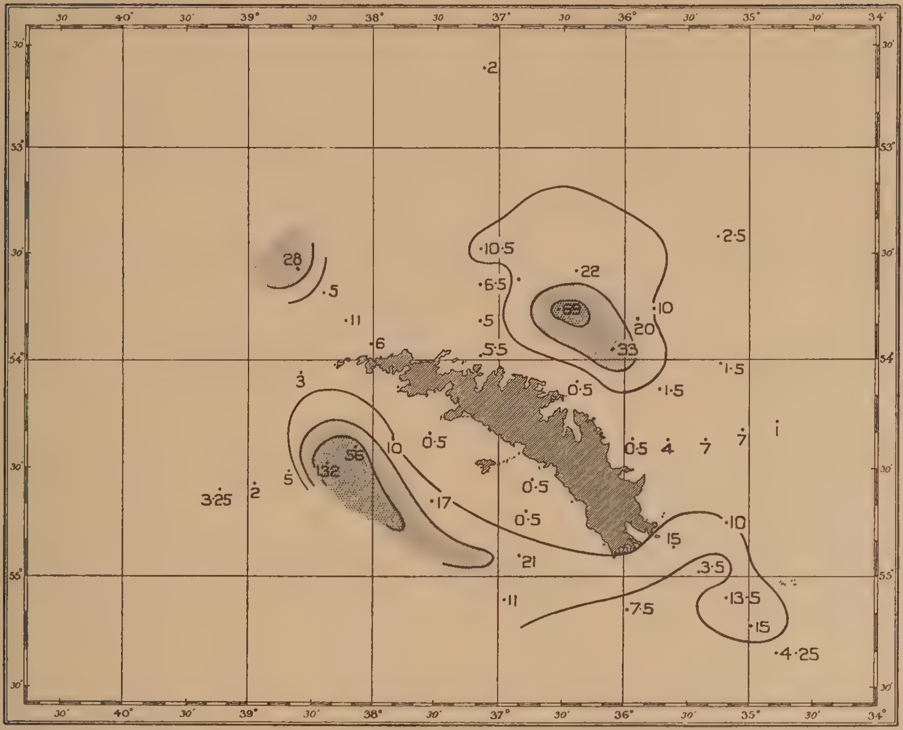

Fig. 40. Contour chart showing the total quantity of phytoplankton in the South Georgia December–January 1926–7 survey measured by settled volumes of samples collected in hauls with the N 50 V net from 100 m. to the surface and expressed in cc. (cf. Fig. 38).

In late May 1927, when the R.R.S. 'William Scoresby' revisited South Georgia, the C line was repeated. There was more phytoplankton than in March 1926, but a marked decrease from the summer months of December and January. *Chaetoceros criophilum*, *Ch. socialis*, *Nitzschia seriata*, *Corethron valdiviae*, *Rhizosolenia styliformis* and *Coscinodiscus* spp. were the prominent forms. Their numbers are shown in Appendix I, Sts. WS 110–114. The nature of this plankton resembled that of our phytoplankton Group 4.

South Georgia to the Falkland Islands

In passing east to west, from South Georgia to the Falkland Islands, we pass from the Antarctic to the sub-Antarctic Zone; see p. 6. The boundary separating the two masses of surface water—the Antarctic Convergence—lies close against WS 67, and WS 68–70 are beyond it in the sub-Antarctic Zone. The set of samples taken across these two water masses is perhaps the most interesting in the present survey. We see a diminution of the phytoplankton both in numbers and in species as we approach the sub-Antarctic area and pass into it. One after another of the Antarctic species is left behind and *Rhizosolenia curva*, a sub-Antarctic species, increases in numbers. This is shown in Table V, where the stations are arranged in geographical order from west to east (in the reverse order to which they were taken) together with St. 161 which lies well in the Antarctic Zone to the south-west of South Georgia (see Fig. 14). All these stations were taken in February 1927: Sts. 160 and 161 on the 7th and 14th; and WS 67–70 from the 20th to the 23rd. The stations in the Antarctic Zone lie in water of Bellingshausen Sea origin and the phytoplankton belongs to our Group 1.

PHYTOPLANKTON PRODUCTION IN RELATION TO HYDROLOGY

In Fig. 38 is shown a chart of the phytoplankton production round South Georgia in the December–January survey, 1926–7, as measured by the number of plant cells taken in hauls with the N 50 V nets from 100 m. to the surface. Fig. 40 shows the production as measured by the volume of settled samples. The disadvantages of these two methods of measuring production are discussed in the previous section. The two methods nevertheless show a pattern of the same general nature and, as already suggested, a true idea of production probably lies between the two. We see that there are two main regions of more intensive phytoplankton production—one a larger one to the west and south-west and a smaller one to the north-east.

Discussing this distribution, particularly the larger area of production to the west and south-west, in a paper giving a preliminary account of the work of the expedition in the *Geographical Journal*, the author (1928) put forward a provisional hypothesis and suggested an explanation thus:

> South Georgia is a long narrow island...placed almost at right angles to the main westerly drift coming up from the Drake Straits. The currents set up round it will be like those set up round any long object forced sideways through a fluid—the water will be forced in a curve round either end to meet in an eddy some distance behind it, leaving an area of "dead" water immediately against the land. The growth of plant life in the sea is limited, as Atkins has shown, by the quantity of available phosphate. This as the summer advances gets used up in the upper layers. Here, where the main ocean current from the west strikes the continental shelf of South Georgia, there will be an upwelling of water rich in phosphate from the deeper layers on the west side of the island. It is here that we get the densest growth of diatoms, which are carried round either end into the area behind the island.

This hypothesis was wrong. Whilst the water movements suggested above were correct for the water at a depth of 150 m., see Fig. 171, our hydrologists have shown that in this survey the conditions nearer the surface were not so simple. They have demonstrated, as Mr Clowes has shown in his water-movement chart, Fig. 6, that there are the two currents, one of Bellingshausen Sea and the other of Weddell Sea origin, and that the latter is curved round by the Scotia arc to arrive at South Georgia from the south-east. The Bellingshausen current curves up the western side of the continental shelf and flows in from the north-west. The two water masses mix on each side of the island, and after coming together again to the north are deflected to the eastward by the main west-wind drift. This is described more fully on pp. 8 and 11. There is probably vertical mixing on the western side; but increased phosphates cannot be the cause of the richer phytoplankton on that side, for our hydrologists, those of the Meteor Expedition (Wattenberg, 1926–7) and Ruud on the Vikingen Expedition (1930), have all shown that there is in these waters always a sufficient supply of phosphates and nitrates to support a heavy phytoplankton crop—nowhere would the production of phytoplankton appear to be inhibited by lack of phosphates as it is in our home waters.[1] The relatively high phosphate content of these surface layers as compared with that of the surface layers of lower latitudes or even of corresponding latitudes in the northern hemisphere is one of the most striking characteristics of the Antarctic Zone. This rich supply of phosphates appears to be locked up in the circulation between the deeper layers of the ocean in lower latitudes and the cold surface water of the Antarctic (see p. 8). The change in phosphate content of the surface water from the Equator to the Antarctic was well shown by Ruud's (1930) surface samples taken on the Vikingen Expedition in 1929, and in greater detail for all depths by the 'Discovery II' in April and May of 1931. The values for depths down to 1000 m. are shown in Table VI, where the figures are taken from the Station List in vol. IV of the *Discovery Reports*. Atkins (1923*a*) has shown for the English Channel that the changes in the phosphate content of the surface layers from 35–40 mg. per cu.m. in mid-winter to 0–5 mg. per cu.m. in summer are correlated with the production of the spring phytoplankton maximum. In 1926 at South Georgia the average phosphate content for the upper 50 m. in December (Antarctic summer) at five stations on the C line off the north-east coast is 95 mg. per cu.m., and at corresponding stations some three weeks earlier it was 110 mg. per cu.m. The phosphate values along these lines may be compared in Table VII. To see a change over a longer period and from winter conditions, we must look beyond our present survey to the data obtained in the surveys of 1928 published in the Station List in vol. III of the *Discovery Reports*.

Table VI

Phosphate estimation expressed as mg. per cubic metre made by the 'Discovery II' on a line of stations along the meridian 30° W from latitude 57° 36′ S to 09° 47′ S, April–May, 1931. Values below 80 in **heavy type**

Station ...	661	663	666	668	671	673	675	677	679	684	687
Lat. S ...	57° 36′	53° 34′	49° 59′	46° 43′	43° 08′	38° 10′	34° 08′	31° 16′	26° 06′	15° 37′	09° 47′
Depth in m.											
0	105	98	105	**79**	**73**	**9**	**10**	**8**	**0**	**0**	**0**
10	104	100	109	**79**	**73**	**9**	**10**	**8**	**0**	**0**	**0**
20	109	98	108	**79**	**71**	**12**	**10**	**8**	**0**	**0**	**0**
30	106	102	109	**79**	**70**	**12**	**10**	**8**	**0**	**0**	**0**
40	106	102	107	80	**69**	**12**	**10**	**8**	**0**	**0**	**0**
50	102	102	106	80	**71**	**12**	**11**	**8**	**0**	**0**	**0**
60	125	102	106	81	**73**	**12**	**13**	**8**	**1**	**0**	**0**
80	129	114	106	89	80	**12**	**13**	**10**	**1**	**0**	**0**
100	130	118	107	94	87	**25**	**13**	**10**	**3**	**2**	**3**
150	141	131	126	102	99	**30**	**22**	**14**	**8**	**4**	**15**
200	145	131	136	110	108	**30**	**34**	**18**	**14**	**8**	**60**
300	141	139	148	110	117	**35**	**35**	**24**	**32**	**57**	91
400	141	131	151	114	125	**76**	**38**	**59**	**52**	**76**	100
600	140	130	144	119	135	91	93	**70**	82	115	130
800	140	130	139	138	142	99	102	114	98	118	132
1000	140	130	137	141	151	139	117	128	137	114	144

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[1] This is further discussed on pp. 85 and 86.

From that list we give in Table VIII the phosphate and oxygen values from the upper 50 m. for stations taken off the north-east coast in late August and also for corresponding stations in late December. We see an average phosphate content for August of 149 mg. per cu.m. and for December 112 mg. per cu.m.; that is a reduction of 37 mg. per cu.m. in four months. Naturally, on account of the flow of currents, the water is not the same as that sampled in August, but presumably it had the same origin and had originally approximately the same phosphate content. In 1926 we saw a reduction of 15 mg. per cu.m. in a little over three weeks between November and December, so it is likely that the greater part of this 37 mg. reduction up to the end of December in 1928 would be made during November and December as the light intensity increased. (We see that the average content for December 1928 is 17 mg. per cu.m. higher than that for December 1926; we do not know whether this was due to less phytoplankton production in 1928 or to a higher initial content at the beginning of the season.)

Table VII

Comparison of phosphate content, expressed in mg. per cu.m., of the top 50 m. on a line of five stations taken off the north-east coast of South Georgia in November 1926 and again a month later

	November 26–30, 1926					December 20–22, 1926				
Station	WS 18	WS 19	WS 20	WS 21	WS 22	130	131	132	133	139
Depth in m.										
0	88	97	89	106	123	83	91	105	95	88
5	93	(125 ?)	93	109	123	85	86	99	94	—
10	98	111	93	123	123	95	91	100	95	90
20	108	106	100	118	123	93	93	99	105	86
30	113	105	103	113	123	93	93	100	96	95
40	118	108	101	119	125	89	95	103	101	96
50	123	111	101	125	125	98	96	105	104	92
Average	106	106	97	116	124	91	92	102	99	91
Grand average	**110**					**95**				

If it can be assumed that at mid-winter the phosphates in the upper layers of a particular stretch of sea are approximately evenly distributed then it would be possible to compare the amount of phytoplankton production that had taken place in different sub-areas as the season advances by studying the differences in phosphate content of these areas later in the season. This assumption is tentatively made by Gran (1931) when he compared the phytoplankton production with phosphate consumption in respect to the samples obtained by Ruud at his fourteen stations in the Weddell Sea. Kreps and Verjbinskaya (1930), estimating phytoplankton by chlorophyll mg. per cu.m., have recently shown from surveys in the Barents Sea how phytoplankton production along a line of stations is accompanied by phosphate and nitrate reductions. The chlorophyll method of Kreps and Verjbinskaya is of great interest because it eliminates the drawbacks, already referred to, involved in estimating phytoplankton production either by counting numbers of plant cells or by measuring volumes.

Table VIII

Comparison of phosphate and oxygen content of the top 50 m. on a line of five stations taken off the north-east coast of South Georgia in August 1928 and again four months later

	August 27–28, 1928					December 27–28, 1928				
Station	WS 257	WS 258	WS 259	WS 261	WS 263	WS 328	WS 329	WS 330	WS 332	WS 334
	P_2O_5 mg. per cu.m.					P_2O_5 mg. per cu.m.				
Depth in m.										
0	143	135	159	138	136	102	102	109	100	112
5	142	135	159	132	132	106	111	112	105	117
10	146	153	159	134	133	102	113	112	107	119
20	146	153	170	148	130	102	120	114	107	119
30	146	153	174	148	163	107	123	114	100	119
40	140	153	180	148	162	111	124	116	105	117
50	133	153	162	155	160	115	127	118	106	120
Average	142	148	166	143	145	106	117	114	104	118
	Oxygen: cc. per litre					Oxygen: cc. per litre				
0	—	—	—	—	—	—	—	—	—	—
5	7·78	7·94	7·79	7·95	7·96	8·05	8·31	8·15	8·26	7·89
10	—	—	—	—	—	—	—	—	—	—
20	7·78	7·84	8·03	7·89	8·02	8·24	8·17	8·13	8·54	7·88
30	—	—	—	—	—	—	—	—	—	—
40	7·76	7·80	7·84	8·01	7·94	8·02	8·08	8·12	8·53	8·03
50	—	—	—	—	—	—	—	—	—	—
Average	7·77	7·86	7·89	7·95	7·97	8·10	8·19	8·13	8·44	7·93
Grand average	P_2O_5 = **149** mg. per cu.m. O = **7·89** cc. per litre					P_2O_5 = **112** mg. per cu.m. O = **8·16** cc. per litre				

Fig. 39 shows a chart of the phosphate content expressed as an average for the top 50 m. round South Georgia in the December–January survey, 1926–7. Arrows indicating the main water movements are shown, but the figure should be compared with the details in Fig. 6. The general similarity in the pattern of both the phosphate and the phytoplankton charts (Figs. 38–40) is striking, the areas of greatest phosphate reduction corresponding with the greatest phytoplankton production.

We will now consider the relationship of phytoplankton production and phosphate reduction in this survey in greater detail, taking each of the lines of stations with their adjacent intermediate stations separately. These lines are referred to as A, B, C, D, E, F and G, corresponding to the lettering used in the temperature and salinity charts in

Figs. 7 and 8 on pp. 12–15. The key chart provided with these figures should be consulted for comparison with the figures in this section. Table IX shows the phytoplankton and phosphate content of the upper 100 m. at stations on the A line (north-west of South Georgia) passing from the outer station WS 30 to the inner station WS 27. St. WS 52 is the intermediate station between the A and G lines. Here we see a close correlation between the higher phytoplankton production and the reduced phosphate content at St. WS 30. As already explained on p. 70 Mr Clowes agrees that the patch of water with high phytoplankton content at St. WS 30, marked with letter B in the phosphate chart, Fig. 39, is likely to be a portion of the area of mixture from further south carried round by the swirl from the region marked A.

Table IX

Phytoplankton and phosphate content, South Georgia survey, December–January 1926–7, *line A*

Station	WS 30	WS 29	WS 28	WS 27	WS 52
Phytoplankton in millions per 50 m. haul with N 50 V net					
Chaetoceros socialis	**16·6**	—	—	—	4·5
Total phytoplankton	**18·2**	0·1	0·5	0·3	4·6
P_2O_5 mg. per cu.m.					
Depth in m.					
0	**78**	104	99	99	103
10	**78**	—	103	98	106
20	**79**	105	105	96	106
30	**88**	100	106	103	104
40	93	113	111	104	103
50	100	116	125	110	110
60	100	124	125	110	113
80	108	132	130	—	116
100	115	142	133	—	125

Table X shows the low phytoplankton and high phosphate content at all stations, passing out from the coast, on the B line (that running due north) and at St. WS 26 between lines A and B.

On the C line (running north-east), and the intermediate stations 124 and 125, shown in Table XI, there is a lower phosphate content down to 40 m. at St. 124, where the phytoplankton is highest.

On the D line (that running almost due east) and the intermediate stations WS 38 and WS 39 between D and C, there is a small phytoplankton production; at the inner stations 134 and 135 the phosphate content is lower than the outer ones. This is well explained by a reference to the water-movement chart Fig. 6 and the phytoplankton chart Fig. 38. The water at the inner stations has flowed round from the western side of the island from the region of heavy phytoplankton production, the phytoplankton having presumably died or been grazed down by zooplankton in transit.[1]

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[1] This is further discussed on p. 84 in reference to the F line.

Table XIII shows the stations on the E line (running out to the south-east) and the intermediate station WS 37 between the E and D lines. At the inner stations there is a striking correlation between the rich phytoplankton and reduced phosphate, except that at St. WS 33 the phytoplankton has apparently declined or been grazed down.

The F line running to the south-west presents an interesting anomaly which is explained by reference to the G line which will therefore be taken out of its turn. The stations on the G line, that running west by south, together with the intermediate

Table X

Phytoplankton and phosphate content. South Georgia survey. December–January 1926–7, line B

Station	126	127	128	129	WS 26
Phytoplankton in millions per 50 m. haul with N 50 V net					
Chaetoceros valdiviae	0·08	0·2	0·2	0·4	—
Total phytoplankton	0·08	0·2	0·2	0·4	—
P_2O_5 mg. per cu.m.					
Depth in m.					
0	99	100	92	99	106
5	100	99	91	103	—
10	108	98	91	106	105
20	105	96	90	98	109
30	108	95	99	95	115
40	106	96	103	93	120
50	110	108	104	93	125
60	111	108	104	101	—
80	115	111	109	94	130
100	119	114	115	106	134

Table XI

Phytoplankton and phosphate content. South Georgia survey. December–January 1926–7, line C

Station	130	131	132	133	139	124	125
Phytoplankton in millions per 50 m. haul with N 50 V net							
Chaetoceros socialis	0·004	3·2	1·0	0·04	—	10·8	1·2
Total phytoplankton	0·005	3·3	1·1	0·03	—	11·1	1·3
P_2O_5 mg. per cu.m.							
Depth in m.							
0	83	91	105	95	88	(144?)*	90
5	85	86	99	94	—	(126?)*	—
10	95	91	100	95	90	88	94
20	93	93	99	105	86	88	93
30	93	93	100	96	95	84	91
40	89	95	103	101	96	86	90
50	98	96	105	104	92	91	94
60	103	99	116	104	94	—	93
80	106	108	116	105	98	96	101
100	108	113	118	110	111	111	105

* Values queried, see Station List, *Discovery Reports*, vol. I.

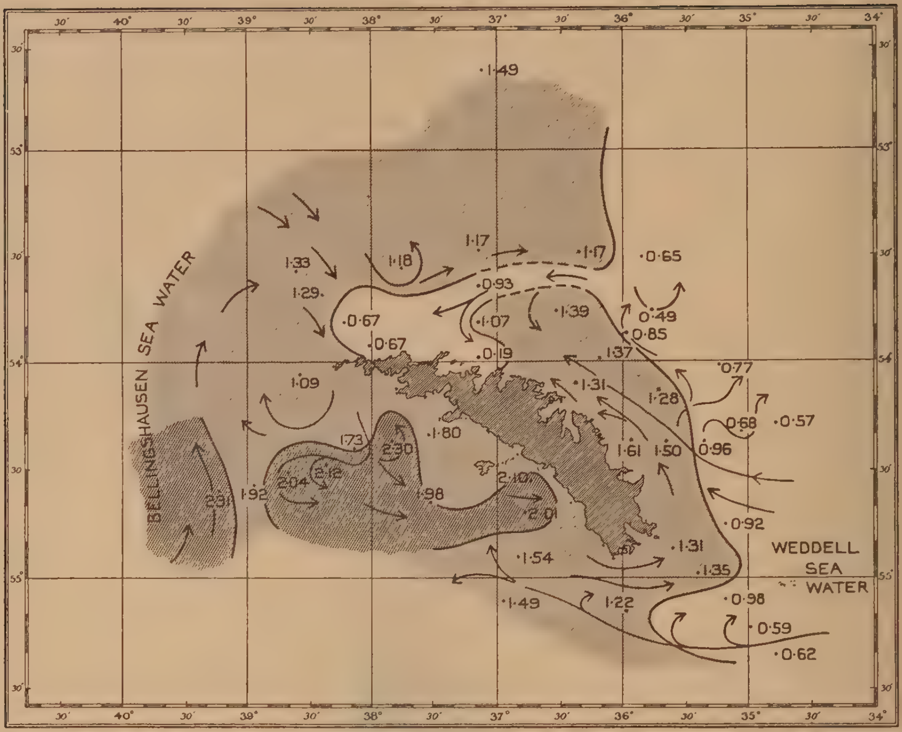
BELLINGSHAUSEN SEA WATER
WEDDELL SEA WATER
1·49
1·17
1·17
0·65
1·18
1·33
1·29
0·93
1·39
0·49
0·85
0·67
0·67
1·07
0·19
1·37
0·77
1·09
1·31
1·28
0·68
0·57
1·80
1·73
2·30
1·61
1·50
0·96
2·12
2·04
1·92
2·31
1·98
2·10
2·01
0·92
1·31
1·54
1·35
1·49
1·22
0·98
0·59
0·62
40°
39°
38°
37°
36°
35°
34°
30′
53°
54°
55°

Fig. 41. Contour chart showing the average temperature in °C. from 50 m. to the surface at stations in the South Georgia December–January 1926–7 plankton survey. The main surface water movements are shown by arrows (cf. Fig. 6).

Table XII

Phytoplankton and phosphate content, South Georgia survey, December–January 1926–7, line D

Station	134	135	136	137	138	WS 39	WS 38
Phytoplankton in millions per 50 m. haul with N 50 V net							
Chaetoceros socialis	—	—	—	1·2	—	—	0·09
Total phytoplankton	0·004	0·1	0·3	1·8	0·006	0·009	0·16
P_2O_5 mg. per cu.m.							
Depth in m.							
0	94	90	(118?)	90	95	94	93
10	93	85	103	93	91	100	94
20	89	85	105	98	91	103	95
30	90	86	105	103	96	105	93
40	91	89	103	103	103	105	93
50	94	90	105	103	104	98	100
60	89	98	103	99	105	98	101
80	99	100	116	101	109	99	103
100	106	94	120	113	119	106	114

Table XIII

Phytoplankton and phosphate content, South Georgia survey, December–January 1926–7, line E

Station	WS 31	WS 33	WS 34	WS 35	WS 36	WS 37
Phytoplankton in millions per 50 m. haul with N 50 V net						
Chaetoceros socialis	97·0	0·2	20·8	5·7	0·1	0·001
Total phytoplankton	97·2	0·3	21·3	8·3	0·6	0·3
P_2O_5 mg. per cu.m.						
Depth in m.						
0	75	74	86	93	91	100
10	80	83	86	96	91	101
20	83	81	88	99	94	104
30	89	75	89	101	94	100
40	94	81	91	100	95	98
50	106	79	94	101	93	99
60	106	80	99	94	98	100
80	—	89	100	93	113	104
100	—	99	110	108	120	105

Table XIV

Phytoplankton, phosphate and oxygen content, South Georgia survey, December–January 1926–7, line G

Station	WS 63	WS 51	WS 50	WS 49	WS 48	WS 47	WS 46	WS 45
Phytoplankton in millions per 50 m. haul with N 50 V net								
Chaetoceros socialis	0·0	0·1	6·0	530·8	502·2	125·8	0·9	49·0
Total phytoplankton	2·6	0·6	6·1	531·2	502·5	126·1	1·0	99·1
P_2O_5 mg. per cu.m.								
Depth in m.								
0	95	88	88	71	88	79	85	80
10	100	88	80	71	88	84	85	80
20	96	90	81	73	83	84	90	75
30	100	89	85	71	84	84	91	79
40	100	93	91	73	90	89	98	83
50	106	95	91	85	96	94	101	83
60	108	103	100	108	103	93	105	100
80	119	118	116	115	104	113	119	110
100	123	121	124	125	123	116	125	120
Oxygen: cc. per litre								
0	7·24	7·41	—	7·88	—	7·34	—	7·69
10	7·16	7·43	—	7·87	—	7·39	—	7·62
20	7·23	7·34	—	7·77	—	7·39	—	7·77
30	7·25	7·43	—	7·73	—	7·33	—	7·76
40	7·26	7·36	—	7·79	—	7·41	—	7·68
50	7·36	7·39	—	7·36	—	7·36	—	7·87
60	7·31	7·32	—	7·34	—	7·42	—	7·54
80	7·15	7·35	—	7·25	—	7·42	—	7·61
100	7·06	6·93	—	7·09	—	7·21	—	7·31

station WS 45 between lines F and G, are shown in Table XIV, where the oxygen content is shown in addition to phosphate and phytoplankton content. This line, with the intermediate station, lies across the region of heavy phytoplankton production to the west of the island. The correlation between the three sets of values needs no comment. This area of intense production corresponds with the area of mixture of Weddell Sea water and Bellingshausen Sea water, an area of warmer water, as is shown in the temperature chart in Fig. 41.

In Table XV we show the phytoplankton, phosphate and oxygen content of the stations on the F line, that running to the south-west, and the intermediate station WS 40 between lines F and E. Here we have at first sight the remarkable anomaly of the outer stations WS 44 and WS 43 and the intermediate station WS 40 having a rich phytoplankton together with a higher phosphate and lower oxygen content than the inner stations WS 42 and WS 41, where the phytoplankton is exceptionally low. The general water movements are shown in the phosphate chart in Fig. 39 and in greater detail in Fig. 6; when these are referred to it will be seen that the inner stations on the F line are in water which has flowed away from the scene of dense phytoplankton production sampled by the G line, whereas the outer stations WS 44 and WS 43 and the intermediate station WS 40 lie in the path of Weddell Sea water flowing in towards this centre of rich production. This must mean that at these stations, as the water is entering the region of mixture with the Bellingshausen Sea water, the intense production of phytoplankton is only just beginning and has not yet had time to cause a marked alteration in the phosphate and oxygen content. The water at the inner stations has flowed from the scene of intense phytoplankton production, where it seems from the water-movement chart that it has been eddying round for some time, giving rise to a marked decrease in phosphate and increase in oxygen content; but for some reason on entering the coastal region the phytoplankton was reduced. Possibly associated with the reduction in this phytoplankton, made up largely of the small *Chaetoceros socialis*, was the presence of vast numbers of the neritic copepod *Drepanopus pectinatus* which were taken at these two inner stations, particularly at St. WS 42, where 2¼ millions were taken in the N 70 H net just below the surface. These copepods in their millions along the edge of the coastal water may have brought about a great reduction in the already declining oceanic diatoms entering the area. The lack of correspondence between the phytoplankton production and phosphate reduction on this F line is important when considering the relationship of zooplankton to phytoplankton in Part V; the majority of exceptions to the working of the principle of animal exclusion there put forward, where the animal plankton is correlated with phytoplankton as measured by phosphate reduction, occur in the region of this line.

It would seem, from this comparison of the phytoplankton production with the phosphate reduction, together with the work of Kreps and Verjbinskaya and of Gran already cited, that phosphate reduction can be used as an approximate indication of the intensities of phytoplankton production in the water of an area, not, it should be pointed out, immediately at the time of the phosphate sampling, but *over a little time in the past.*

Allen (1928) and Moberg (1928) have shown how the upwelling of phosphates and nitrates against the coast of South California can give rise to a zone of rich phytoplankton, but we have seen that such cannot be the explanation of such zones against the coasts of South Georgia. One may speculate whether this rich phytoplankton is caused by some other factor present in the upwelling water—other salts or the resting spores of diatoms themselves—or again whether it is due, as Gran (1931) has recently shown can sometimes be the case, to organic iron compounds carried out from the land. At present, however, we must admit that we have no definite evidence of the cause, and this is one of the important problems upon which it is hoped future work will throw light. It may be found on different occasions to be due to different causes, and I would draw attention to the following points which might form the basis of a further working hypothesis. Not only is it seen that the pattern of phytoplankton production round South Georgia corresponds remarkably well with that of phosphate consumption, but on comparing Figs. 38 and 40 with Fig. 6 it is seen that the areas of denser production correspond with those areas shown by Mr Clowes in his water-movement chart to be the areas of mixing of the two water systems. In the preliminary account of the expedition in the *Geographical Journal* (1928) already referred to, I showed a chart of the production of phytoplankton in the region of the South Shetlands measured in volumes—measure-

Table XV

Phytoplankton, phosphate and oxygen content, South Georgia survey, December–January 1926–7, line F

Station	WS 44	WS 43	WS 42	WS 41	WS 40
Phytoplankton in millions per 50 m. haul with N 50 V net					
Chaetoceros socialis	**49·0**	**57·1**	—	—	**89·0**
Total phytoplankton	**143·8**	**101·6**	0·02	0·003	**193·3**
P_2O_5 mg. per cu.m.					
Depth in m.					
0	98	91	**75**	**75**	100
10	101	91	**73**	**79**	91
20	110	93	**78**	**78**	91
30	103	91	**76**	**79**	91
40	104	94	**80**	**80**	96
50	105	100	**86**	**88**	95
60	113	105	105	104	103
80	118	115	115	116	115
100	125	125	125	125	119
Oxygen: cc. per litre					
0	7·46	—	**7·61**	—	7·54
10	7·36	—	**7·63**	—	7·59
20	7·33	—	**7·50**	—	7·17
30	7·29	—	7·48	—	7·49
40	7·28	—	**7·64**	—	7·45
50	7·29	—	**7·73**	—	7·41
60	7·18	—	7·35	—	7·35
80	7·20	—	7·19	—	7·26
100	7·05	—	7·40	—	7·14

ments taken at the time of the survey after the samples had settled for over 24 hours. There was a belt of phytoplankton along by the South Shetlands, and an area of low phytoplankton production on the southern side of the Bransfield Straits. Our hydrologists have shown that there is an influx of water into the Bransfield Straits from the Weddell Sea. Here we see the warmer Bellingshausen Sea water meeting the colder Weddell Sea water, and, as at South Georgia, at the region of their mixture there is the denser production of phytoplankton. St. 161 in mid-ocean showed a dense production of phytoplankton, and this station, although in Bellingshausen Sea water, lies close against the border separating it from Weddell Sea water, and along this border there may be a wide area of mixture. In the southern North Sea dense patches of phytoplankton are often produced in the region where the water flowing from the north meets and mixes with that entering from the south through the English Channel. The hypothesis I would tentatively suggest, to be considered with others, is that the mixing of two different water systems, in providing a change of environment, is a cause of high productivity (provided of course that sufficient nutritive salts are present, as in the Antarctic is certainly the case). It is well known that Protozoa will go on multiplying in cultures for a period of time, but that then a period of depression sets in when they divide less and less frequently and the culture dies down to a low level in spite of the fact that conditions of the culture medium are kept constant. Calkins (1902–4) showed that in cultures of *Paramoecium* the periods of depression might for a time be overcome by a change in the nature of the culture medium, or by temporary treatment with simple salt solutions. Control animals not so treated died out at the end of about six months, whilst those treated with a change in environment entered upon a new cycle. He expresses the view that such depressions can probably be overcome "in nature by opportune changes in the immediate environment". The view is held that the protoplasm becomes too stabilized in relation to environmental conditions that persist unchanged for a long time, and that from time to time a change of environment is required to enable metabolism to proceed at its fuller rate leading to active division.[1] Possibly over stretches of ocean where conditions become comparatively uniform diatoms may decline into a phase of inactivity, to be awakened to an outburst of new life on coming into a changed environment by mixing with water of slightly different constitution, either by meeting another surface current or by an upwelling of water, or perhaps by the effects of melting ice. If the hypothesis should be proved correct it would of course only carry one a step further. It would remain to investigate exactly what sort of changes are necessary in the environment to bring about the required change in the protoplasmic-environmental relationship. It is possible of course that the mere fact of the colder water of the Weddell Sea current meeting the warmer water of the Bellingshausen Sea current may bring about an active propagation of the cells carried in the former, e.g. *Chaetoceros socialis* on the western side.

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[1] It has been suggested that sex, before it became of evolutionary significance in bringing about a re-assortment of the genetical factors, arose as a fusion of two cells to bring about a change in the protoplasm in relation to its environment. It is true that since this idea was put forward certain strains of *Paramoecium* have been kept alive by Woodruff and others for a very long period without being allowed to conjugate, but nevertheless in other strains periodic conjugation or the process of endomixis appears to be necessary. Referring to the auxospores of diatoms Lebour (1930) states that "These are most often, if not always, asexual in the centricate forms...but in the pennate diatoms the auxospores may be formed sexually by conjugation". The majority of oceanic diatoms belong to the centricate division, and whilst highly speculative it seems possible that the mixing of different water masses by the flowing together of ocean currents might bring about a change in the protoplasm-environment relationship which might be necessary for continued propagation in the absence of syngamy.

SEASONAL CHANGES IN THE PHYTOPLANKTON

It is impossible to draw more than the most slender and general conclusions from the data of the present survey. When the results of the surveys of subsequent years are published there should be sufficient data to form a more adequate idea of the changes taking place. In the present survey we can but compare the N 50 V net results taken on the C line in December 1926, March 1926, and late May 1927. March 1926 we have seen was remarkably poor in phytoplankton (p. 73); it gives an average total of but 18,000 phytoplankton organisms for the three N 50 V nets taken. It may have been an exceptional year, and since it belongs to a different season from that of December 1926 and May 1927 it should not be compared with these two. A comparison between the N 50 V nets on the C line of December and May of the same season gives an average total of phytoplankton organisms for December as 1,143,000 as compared with 65,000 for May. This we can provisionally take as an indication of the change taking place between early summer and late autumn.

Again, since our autumnal data are based on only five stations in one locality it is unwise to attempt to draw conclusions as to the succession of species throughout the year. We can, however, say that our results confirm those of Mangin (1915), that *Coscinodiscus bouvet*, *Thalassiosira antarctica* and *Biddulphia seriata* are characteristic of the spring and early summer.[1] There are indications that *Chaetoceros atlanticus* is a late summer and autumn species.

Tables XLVIII and XLIX, showing the seasonal changes in temperature off the north-east coast of South Georgia, are given in the section dealing with seasonal changes in the zooplankton on pp. 265–267.

ARCTIC AND ANTARCTIC PHYTOPLANKTON

Karsten (1905) and Mangin (1915, 1922) have already discussed in detail the comparison of the Arctic and Antarctic phytoplankton. We may state here, however, that the following northern forms were recorded in our catches; those printed in heavy type appear to be recorded in the Antarctic for the first time:

Coscinodiscus centralis
C. concinnus
C. curvatulus
C. excentricus
C. lineatus
C. sub-bulliens?
C. subtilis
C. stellaris
Actinoptychus undulatus
Asteromphalus hookeri
Rhizosolenia alata
Rh. obtusa
Rh. shrubsolei
Rh. styliformis
Chaetoceros dichaeta
Ch. atlanticus
Ch. socialis
Ch. tortissimus
Nitzschia seriata
Peridinium depressum
Dinophysis ovum
Ceratium gibberum
C. tripos atlantica
Halosphaera viridis
Distephanus speculum

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[1] These conclusions are further confirmed by Hart's (1934) results.

PART III. THE ZOOPLANKTON

SECTION I

By E. R. Gunther, M.A. and A. C. Hardy, M.A.

INTRODUCTION

The methods of collection have already been described on pp. 17–19. The 70 cm. diameter nets, hauled both vertically (N 70 V) and horizontally (N 70 H), were used for the capture of the smaller and medium-sized forms, and the 100 cm. diameter nets (N 100 H), towed horizontally, were used for the larger forms. The distribution of the Tintinnidae, which are too small to be taken in representative numbers by the N 70 V nets, has been obtained from the N 50 V samples.

As with the phytoplankton, no attempt has been made in the present work to identify specifically all the forms met with; the object has been to gain a knowledge of only the more important elements of the plankton community. It aims at laying the foundations for a study of the ecology of the plankton which may be added to by future surveys. The identifications in some groups have been carried farther than in others when we have had the assistance of experts in these particular groups; thus the late Mr Andrew Scott has identified nearly all the species of Copepoda. All the material is kept and it is hoped that in time systematic reports on all the groups will appear.

Our previous knowledge of the zooplankton of the Antarctic is based on the collections made by a number of expeditions from the voyage of the 'Challenger' onwards. These expeditions were not concerned with studying the ecology of the plankton, and the reports on the collections are mainly systematic in character. The more important former records of the different species are referred to in the text, and for the sake of brevity, when making such references, the full name of the expedition will not be given, but usually only the name of the ship, together with the name of the author of the particular report concerned. The following list, arranged in chronological order, gives the fuller titles and dates of the expeditions referred to:

'Challenger.'	Voyage of H.M.S. 'Challenger', 1872–6.
'Belgica.'	Expédition Antarctique Belge, 1897–9.
'Valdivia.'	Deutschen Tiefsee-Expedition, 1898–9.
'Southern Cross.'	British Antarctic Expedition, 1898–1900.
'Discovery.'	National Antarctic ('Discovery') Expedition, 1901–4.
'Antarctic.'	Swedish Antarctic Expedition, 1901–3.
'Gauss.'	Deutschen Südpolar-Expedition, 1901–3.
'Scotia.'	Scottish National Antarctic Expedition, 1902–4.
'Française.'	Expédition Antarctique Française, 1903–5.
'Nimrod.'	British Antarctic Expedition, 1907–9.
'Pourquoi-Pas?.'	Deuxième Expédition Antarctique Française, 1908–10.
'Terra Nova.'	British Antarctic ('Terra Nova') Expedition, 1910–13.
'Aurora.'	Australian Antarctic Expedition, 1911–14.
'Endurance.'	Shackleton's Expedition of 1914–17.
'Norvegia.'	Norwegian Antarctic Expedition, 1927–9.
'Vikingen.'	Norwegian Antarctic Whaling Expedition, 1929–30.

As with the phytoplankton, see p. 40, the numbers of zooplankton organisms are recorded as numbers per haul with the different nets for particular lengths of tow specified, and not as numbers per cubic metre of water. In charts comparing the plankton at different stations in the survey, the numbers are expressed in similar specified units, for example numbers per 50 m. vertical haul with the N 70 V nets or numbers per 1 mile tow with three N 100 H nets. If the nets filtered a column of water equivalent to that passing through the ring of the net if no net was attached, then the N 70 V nets would sample 19·25 cu.m. in a 50 m. haul and the N 100 H nets would sample approximately 1850 cu.m. for every mile tow. Actually not all this quantity of water will be filtered, but if we wish to arrive at a minimal figure for animal life per cubic metre we may divide the figures given by the two nets accordingly.

LIST OF ZOOPLANKTON SPECIES

Those shown in **heavy type** were the more important in the present survey.

PROTOZOA

FORAMINIFERA

Globigerina conglomerata, Schwager.
G. bulloides, d'Orbigny.
G. dutertrei, d'Orbigny.
G. pachyderma (Ehrenberg).
G. triloba, Reuss.
Globorotalia (*Pulvinulina*) *scitula* (Brady).

RADIOLARIA

Inter alia:
Aulosphaeridae.
Protocystis (*Challengeria*) sp.
Coelodendrum sp.
Porospathis sp.

CILIATA

Tintinnidae.

COELENTERATA

ANTHOMEDUSAE

Catablema weldoni, E. T. Browne.
Sibogita borchgrevinki, E. T. Browne.

LEPTOMEDUSAE

Cosmetirella sp.

NARCOMEDUSAE

Pegantha sp.
Solmundella sp.

TRACHYMEDUSAE

Botrynema brucei, E. T. Browne.
Homoeonema sp.
Trachynemidae.

SIPHONOPHORA

Chuniphyes multidentata, Leres and Van Riemsdigk.
Crystallophyes amygdalina, Moser.
Dimophyes arctica (Chun).
Diphyes antarctica, Moser.
Galeolaria truncata (Sars).
Hippopodius serratus (?), Moser.
Praya cymbiformis (Delle Chiajé).
P. diphyes, Vogt.
Pyrostephos vanhoffeni, Moser.
Thalassophyes crystallina, Moser.

CTENOPHORA

***Beroë*,** sp.
Pleurobrachia sp.

NEMERTINEA

Pelagonemertes sp.

CHAETOGNATHA

Eukrohnia hamata (Möbius).
Sagitta maxima (Conant).
S. planktonis, Steinhaus.
S. gazellae, Ritter-Záhony.

POLYCHAETA

Harmothoë benthophila var. *bimucronata*, Fausch.
Maupasia caeca, Viguier.
Phalacrophorus pictus, Greeff.
Pelagobia longicirrata, Greeff.
Sagitella cornuta, Ehlers.
Tomopteris carpenteri, Quatrefages.
T. septentrionalis, Quatrefages ex Steenstrup.
Travisiopsis sp.
Typhloscolex mulleri, Busch.
Typhloscolex sp.
Alciopid larvae.

CRUSTACEA

OSTRACODA

Conchoecia hettacra, Müller.
C. antipoda, Müller.
C. elegans, G. O. Sars.
C. hyalophyllum, Claus.
C. obtusata, G. O. Sars.
C. rotundata, Müller.
C. symmetrica, Müller.
Conchoecia spp.

COPEPODA GYMNOPLEA

Calanidae:
Calanus simillimus, Giesbr.
C. minor, Claus.
C. propinquus, Brady.
C. acutus, Giesbr.
Eucalanus elongatus (Dana).
E. acus, Farran.
Eucalanus sp.
Rhincalanus gigas, Brady.
R. nasutus, Giesbr.
Rhincalanus sp.
Calocalanus styliremis, Giesbr.
Clausocalanus laticeps, Farran.
C. arcuicornis (Dana).
C. furcatus (Brady).
Ctenocalanus vanus, Giesbr.
Microcalanus pygmaeus, G. O. Sars.
Microcalanus sp.
Drepanopus pectinatus, Brady.
Spinocalanus abyssalis, var. *pygmaeus*, Farran.
S. horridus, Wolf.
S. magnus, Wolf.
Spinocalanus sp.
Aetidius armatus (Boeck).
Gaidius intermedius, Wolf.
G. tenuispinus (Sars).
Gaidius sp.
Drepanopsis frigidus, Wolf.
Pseudochirella notacantha, G. O. Sars.
P. pustulifera, G. O. Sars.
Gaetanus antarcticus, Wolf.
Undeuchaeta major, Giesbr.
Euchirella hirsuta, Wolf.
E. rostrata (Claus).
E. spinosa, Wolf.
Pareuchaeta antarctica Giesbr.
P. farrani (With).
P. biloba, Farran.
P. scotti, Farran.
Pareuchaeta sp.
Xanthocalanus gracilis, Wolf.
Onchocalanus cristatus, Wolf.
O. magnus, Wolf.
Onchocalanus sp.
Cornucalanus magnus, Wolf.
Cephalophanes frigidus, Wolf.
Cephalophanes sp.
Scolecithrix polaris, Wolf.
S. valida, Farran.
S. ovata, Farran.
S. emarginata, Farran.
Scolecithrix spp.
Scaphocalanus affinis, G. O. Sars.
S. brevicornis (Sars).
S. echinatus (Farran).
Scaphocalanus sp.
Scolecithricella minor (Brady).
S. glacialis (Giesbr.).
Racovitzanus antarcticus, Giesbr.

Centropagidae:
Pleuromamma robusta (F. Dahl).
P. abdominalis (Lubbock).
P. xiphias, Giesbr.
P. gracilis (Claus).
Metridia gerlachei, Giesbr.
M. lucens, Boeck.
M. brevicauda, Giesbr. Two forms.
M. princeps, Giesbr.
Lucicutia magna, Wolf.
L. maxima, Steuer.
L. frigida, Wolf.
Disseta palumboi, Giesbr.
Heterorhabdus austrinus, Giesbr.
H. compactus, G. O. Sars.
Heterorhabdus sp.
Heterostylites, ? *major* (Dahl).
Haloptilus fons, Farran.
H. ocellatus, Wolf.
H. oxycephalus, Giesbr.
Augaptilus megalurus, Giesbr.
Augaptilus sp.
Euaugaptilus sp. juv.
Centraugaptilus rattrayi, T. Scott.
Pachyptilus sp.
Phyllopus bidentatus, Brady.
P. ? *helgae*, Farran.

Candaciidae:
Candacia falcifera, Farran.
Candacia sp.n.
Candacia sp.
Bathypontia sp.

COPEPODA PODOPLEA

Mormonillidae:
Mormonilla phasma, Giesbr.

Cyclopidae:
Oithona frigida, Giesbr.
O. similis, Claus.
Oithona sp.

Harpacticidae:
Microsetella norvegica (Boeck).
Clytemnestra rostrata, Brady.

Oncaeidae:
Oncaea conifera, Giesbr.
O. curvata, Giesbr.
O. notopus, Giesbr.
Oncaea sp.
Conaea rapax, Giesbr.
Lubbockia ? *glacialis*, Sars.

AMPHIPODA

Cyllopus magellanicus, Dana.
C. lucasii, Bate.
Hyperoche medusarum (Krög.).
Pseudorchomene coatsi (Chilton).
Parathemisto gaudichaudi (Guér.).
Phronima sedentaria (Forsk).
Primno macropa, Guér.
Vibilia antarctica, Stebb.

ISOPODA

Munnopsid larva.
Rhabdocheirus sp.

EUPHAUSIDACEA

Euphausia frigida, Hansen.
E. superba, Dana.
E. lucens, Hansen.
E. longirostris, Hansen.
E. triacantha, Holt and Tattersall.
E. vallentini, Stebbing.
Thysanoessa macrura, G. O. Sars.
T. vicina, Hansen.

MYSIDACEA

Antarctomysis maxima, Holt and Tattersall.

DECAPODA

PTEROPODA

Cleodora sulcata (Pfeffer).
Clione antarctica, E. A. Smith.
Limacina balea, Möller.
L. helicina (Phipps).
Spongiobranchea australis, d'Orbigny.

ECHINODERMATA

Auricularia antarctica, MacBride.

TUNICATA

Oikopleura spp.
Salpa fusiformis, var. ***aspera*** (Cham.).

COMPARISON OF THE COMPOSITION OF THE CATCHES OF THE DIFFERENT NETS

Before passing to a description of the distribution of the different organisms as revealed by the N 70 V, N 70 H and N 100 H nets it may be convenient to put on record here the relative composition of the catches of the three nets. The figures about to be given are based on catches taken in the top 250 m. of water only. Such differences as there are between the composition of the catches of the N 70 net used vertically and horizontally may be attributed largely to the fact that whereas the N 70 V net was always used from 250 m. to the surface (when soundings allowed of it), the N 70 H nets were usually confined to the top 150 m. Both Protozoa and Polychaeta occurred in larger numbers between 250 and 100 m. than between 100 m. and the surface, and so form a higher percentage of the catch of the N 70 V than of the N 70 H: the Copepod *Drepanopus* on the other hand is confined to the upper layers and to regions near the coast, so that it figures as a higher percentage in the N 70 H nets. The difference between the catches of the N 100 H and the N 70 nets is of course due to the larger mesh of the former net, which was specially designed to capture the larger forms and eliminate the smaller forms sampled by the other nets. The diatoms have been excluded from these calculations, the percentages being based on the numbers of zooplankton organisms taken throughout the survey.

If we divide the total zooplankton organisms into Copepoda and other organisms we get the following percentages of the catch:

	N 70 V	N 70 H	N 100 H		N 70 V	N 70 H	N 100 H
Copepoda	87·0	93·2	19·2	Other organisms	13·0	6·8	80·8

If we now consider the Copepoda only we get the following percentages:

	N 70 V	N 70 H	N 100 H		N 70 V	N 70 H	N 100 H
Cyclopoidea	48·0	49·7	—	*Oncaea*	1·1	0·02	—
Calanus	4·7	1·6	52·3	*Pareuchaeta*	0·1	0·01	5·0
Ctenocalanus	9·0	2·1	—	*Rhincalanus*	0·7	0·1	27·9
Drepanopus	29·7	37·2	—	*Scolecithricella*	0·5	0·01	—
Metridia	2·0	0·1	0·06	Other Copepoda	3·9	9·16	14·74
Microcalanus	0·3	—	—				

Considering only the organisms other than the Copepoda we get the following percentages:

	N 70 V	N 70 H	N 100 H		N 70 V	N 70 H	N 100 H
Protozoa	50·0	8·2	0·02	Euphausiidae larvae	1·4	3·1	8·8
Chaetognatha	1·7	0·5	1·2	*Limacina balea*	0·3	0·1	0·8
Tomopteris	0·06	0·02	0·5	*L. helicina*	—	—	2·6
Polychaeta ex *Tomopteris*	4·7	2·0	—	Salps	0·3	0·1	4·8
Parathemisto	0·4	0·5	9·9	*Appendicularia*	1·4	0·5	—
Euphausiïdae adult	0·4	2·1	65·4	Remainder	39·34	82·88	5·98

DISTRIBUTION OF ZOOPLANKTON

PROTOZOA

The Protozoa recorded fall into one or other of the three groups: Foraminifera, Radiolaria and Tintinnidae. It was not possible in the time available for the analysis of the large number of samples to carry out specific identification of the Protozoa, and the members of the three groups have simply been recorded as such, with the exception of certain of the Radiolaria, which have been grouped according to the genera or families to which they belong. Whilst it is realized that the results in this form can be of little value, they are included in the present report to give an indication of the relative strength of the three groups in the plankton samples from the different regions under consideration.

Foraminifera

Mr Heron-Allen and Mr Earland, who have been engaged on systematic reports on the Foraminifera, have kindly informed us that the following planktonic species are included amongst those collected:

Globigerina conglomerata, Schwager.
G. bulloides, d'Orbigny.
G. dutertrei, d'Orbigny.
G. pachyderma (Ehrenberg).
G. triloba, Reuss.
Globorotalia (*Pulvinulina*) *scitula* (Brady).

Here we can only deal with the distribution of the Foraminifera in general, as a group. On approaching South Georgia from Tristan da Cunha in February 1926, very few were met with; these occurred in the top 100 m. at St. 10 north of the Antarctic Convergence; in the top 50 m. at St. 11 just south of the Antarctic Convergence and from 500 to 100 m. at St. 12 in the Antarctic Zone, i.e. in water just below the cold Antarctic surface layer where this water is mixing with the warmer intermediate layer below.

In the December-January survey round South Georgia 1926–7 they were taken in considerable numbers (Fig. 42), being distributed more or less equally to the east, west and south, and in smaller numbers to the north. They occurred in larger numbers over deep water away from the coast, and the greatest numbers were taken at depths between 250 and 50 m., although at some stations they occurred in fair numbers in the cold surface layer (see Fig. 43). They also extended down into the zone of pure warm intermediate water. In November 1926 the numbers on the C line were not markedly different from those of December, whilst in the following May, Fig. 42, very few were taken. Between South Georgia and the Falkland Islands in February 1927, large numbers were taken at St. WS 69 across the line of Antarctic Convergence at depths between 250 m. and the surface with smaller numbers extending down to 750 m. (see Fig. 44). At St. WS 70 only a few were taken between 750 and 500 m. A detailed statement of their distribution is tabulated in Appendix II.

Globigerina conglomerata has not been recorded before in the Antarctic Zone. *G. bulloides* is a cosmopolitan species, being most abundant in the tropical seas but extending in small numbers both into the Arctic and Antarctic, where in the higher latitudes its place is taken by *G. dutertrei* and *G. pachyderma* (see Heron-Allen and Earland (1922)).

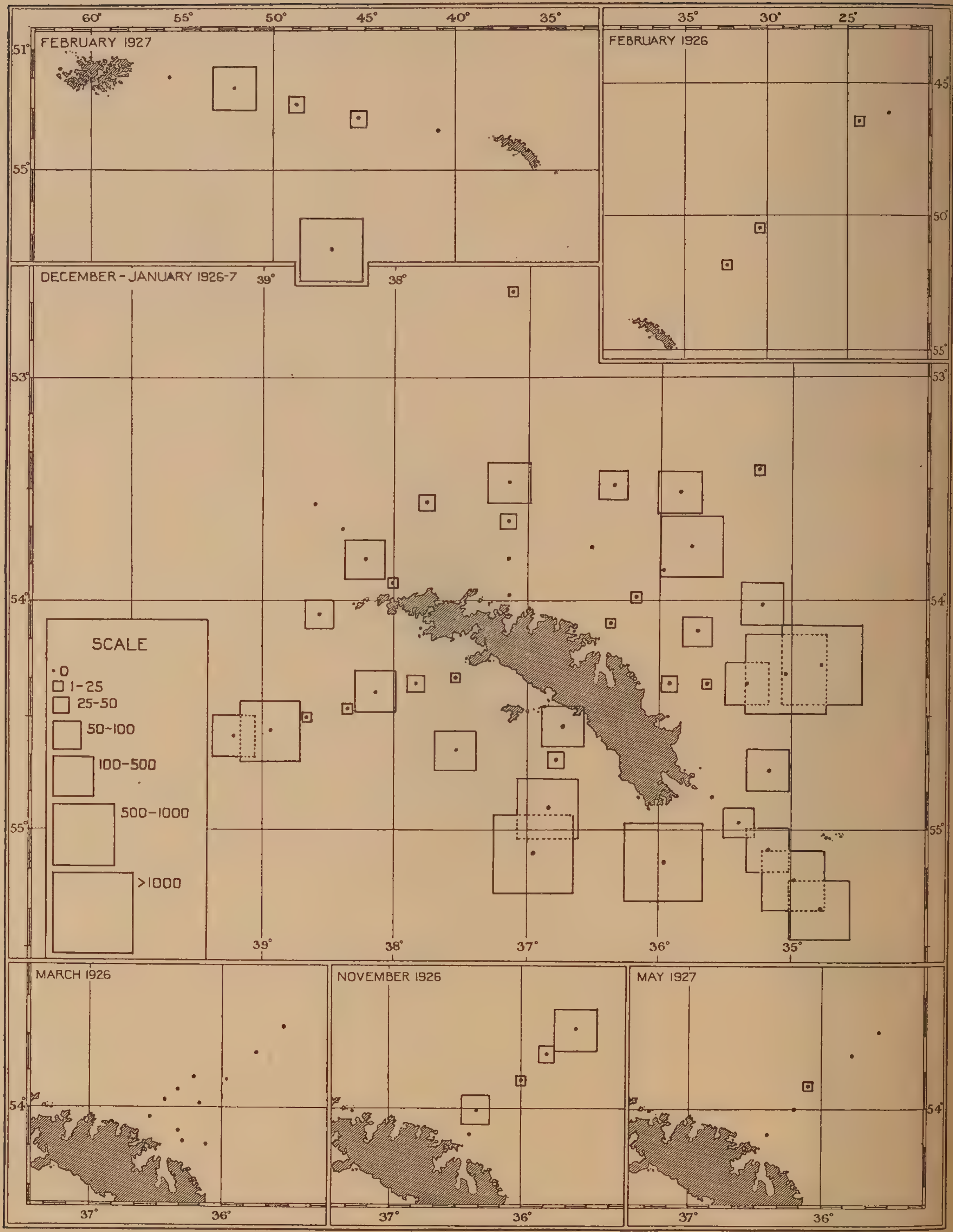
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
• 0
☐ 1-25
☐ 25-50
☐ 50-100
☐ 100-500
☐ 500-1000
☐ >1000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 42. Charts showing the distribution of Foraminifera in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

Wiesner (1931) in his report on the Foraminifera collected by the 'Gauss' records *G. bulloides* from 8° 8′ S to 66° 2′ S. Their observations in the Antarctic lay between 80° and 89° E, but the species is circumpolar. It was taken in large numbers at Port Foster and elsewhere by the 'Pourquoi-Pas?', was the most common species of the genus in the collection made by the 'Scotia'[1] in the Weddell Sea sector and was universally found in the samples obtained by the 'Terra Nova'.[2]

G. pachyderma is bipolar in its distribution, being regarded as a cold-water variety of *G. dutertrei*, occurring only in the colder water of the Arctic and Antarctic. It was also circumpolar, being collected by the 'Gauss',[3] 'Scotia'[1] and 'Terra Nova'.[2]

Globorotalia (*Pulvinulina*) *scitula* does not appear to have been recorded previously in the Antarctic Zone. *G. canariensis* was taken by the 'Scotia'[1] in the Antarctic and by the 'Terra Nova'[2] but not south of the New Zealand area.

Radiolaria

The distribution of the Radiolaria, taken as a whole, is shown in Fig. 45 and tabulated in Appendix II. It is seen that with the exception of stations on the B and D lines (Sts. 126–128 and 135) they occurred in the greatest numbers over the deep water beyond the edge of the continental shelf, rarely being carried into the shallow water. Slightly more were taken on the line between South Georgia and the Falkland Islands in February 1927 than on the line approaching South Georgia from Tristan da Cunha in February 1926.

Radiolaria were scarce to the east of South Georgia in March 1926, Sts. 13–21 and 30–31; and also in May 1927, Sts. WS 110–114.

The vertical distribution of the Radiolaria is shown in Figs. 46 and 47; they occurred in the cold Antarctic surface layer, in the warmer intermediate layer and in small numbers in the cold bottom layer.

Amongst the Radiolaria taken the following families and genera have been recognized:

AULOSPHAERIDA

St. 12 ... ... 40 at 500–250 m.
St. WS 21 ... 50 at 250–100 m.

CHALLENGERIDA

St. 11 ... ... 40 at 500–250 m.
St. 12 ... ... 40 at 500–250 m.
St. 16 ... ... 1 at 500–250 m.
St. WS 51 ... 30 at 100–50 m.
St. WS 51 ... 40 at 200–100 m.

St. WS 63 ... 60 at 250–100 m.
St. WS 68 ... 60 at 750–500 m.
St. WS 110 ... 240 at 500–250 m.
St. WS 110 ... 47 at 750–500 m.
St. WS 110 ... 120 at 1000–750 m.

COELODENDRIDA

St. 9 ... ... 160 at 250–100 m.

POROSPATHIDA

Porospathis sp.

St. WS 68 ... 60 at 750–500 m.
St. WS 110 ... 60 at 1000–750 m.

Each of these groups was taken by the 'Gauss' (Schröder, 1913) in the Antarctic.

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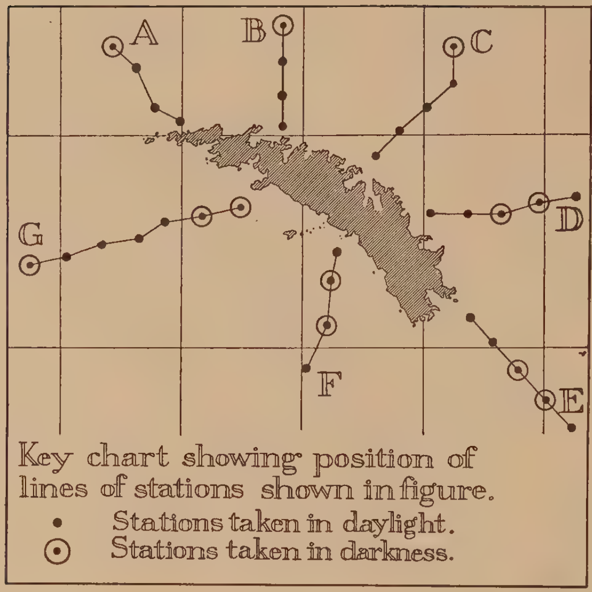
[1] Pearcey (1914). [2] Heron-Allen and Earland (1922). [3] Wiesner (1931).


A
B
C
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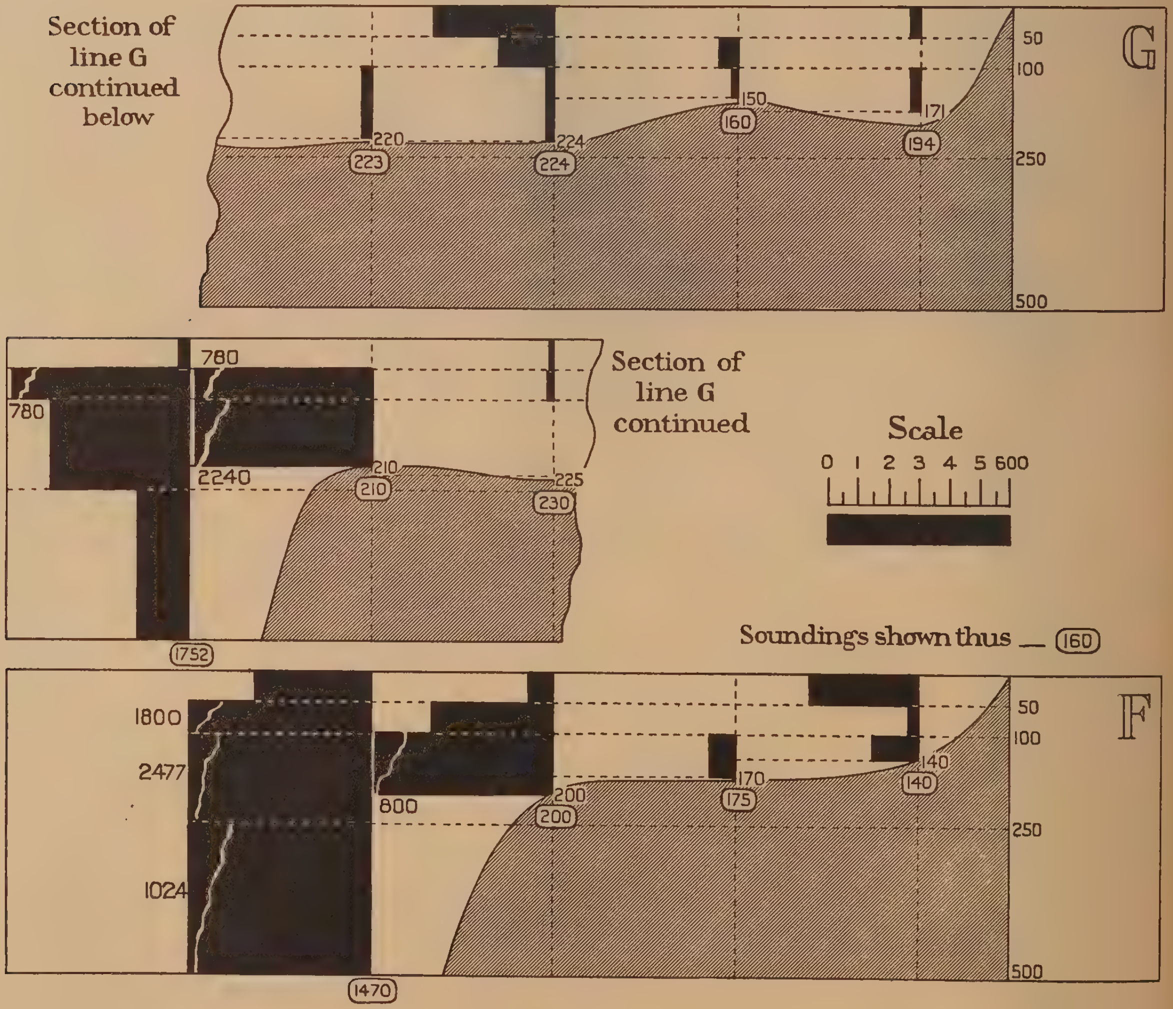
G
Key chart showing position of lines of stations shown in figure.
● Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 43. Showing the vertical distribution of

Foraminifera

down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



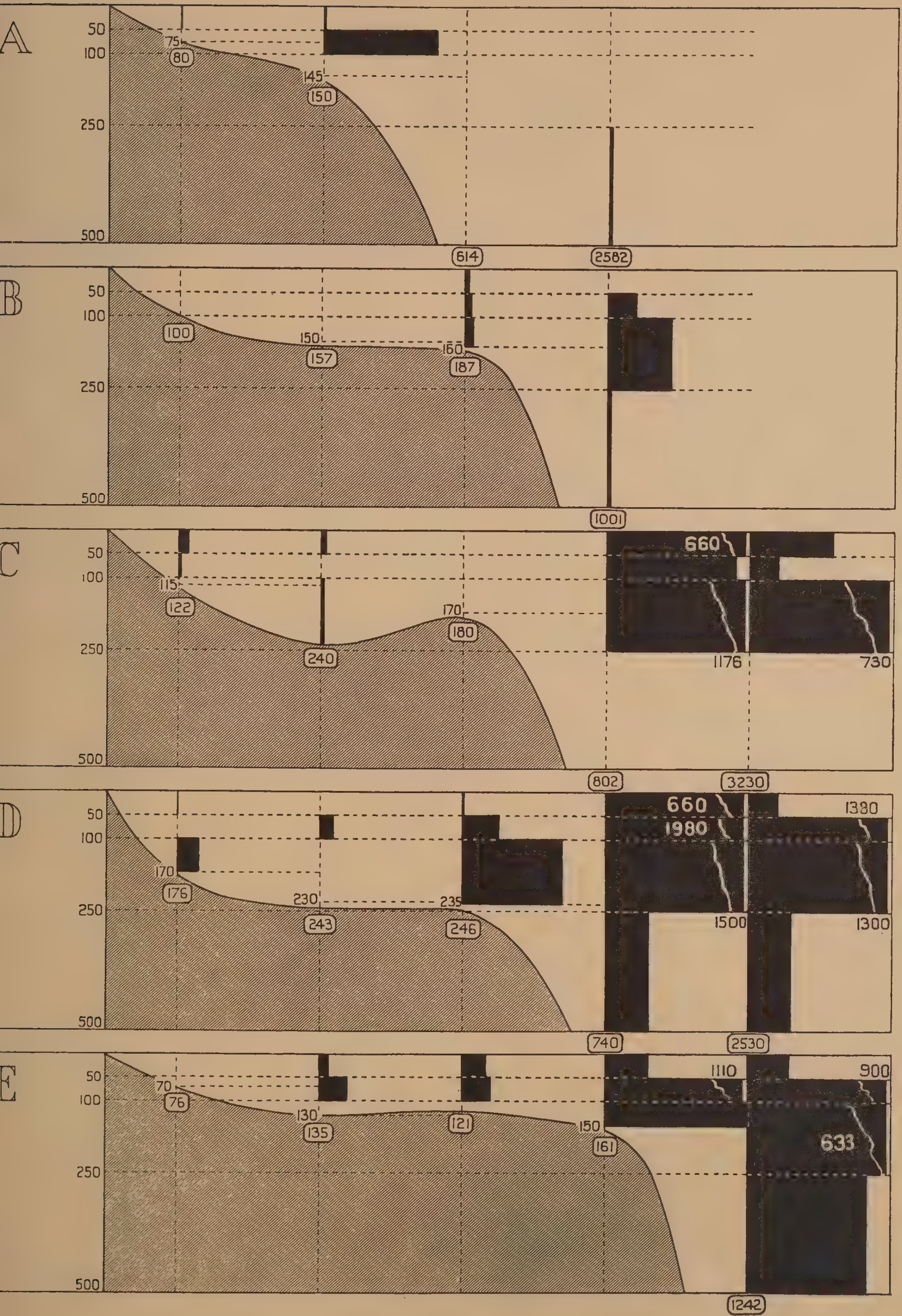


Fig. 43—*continued*

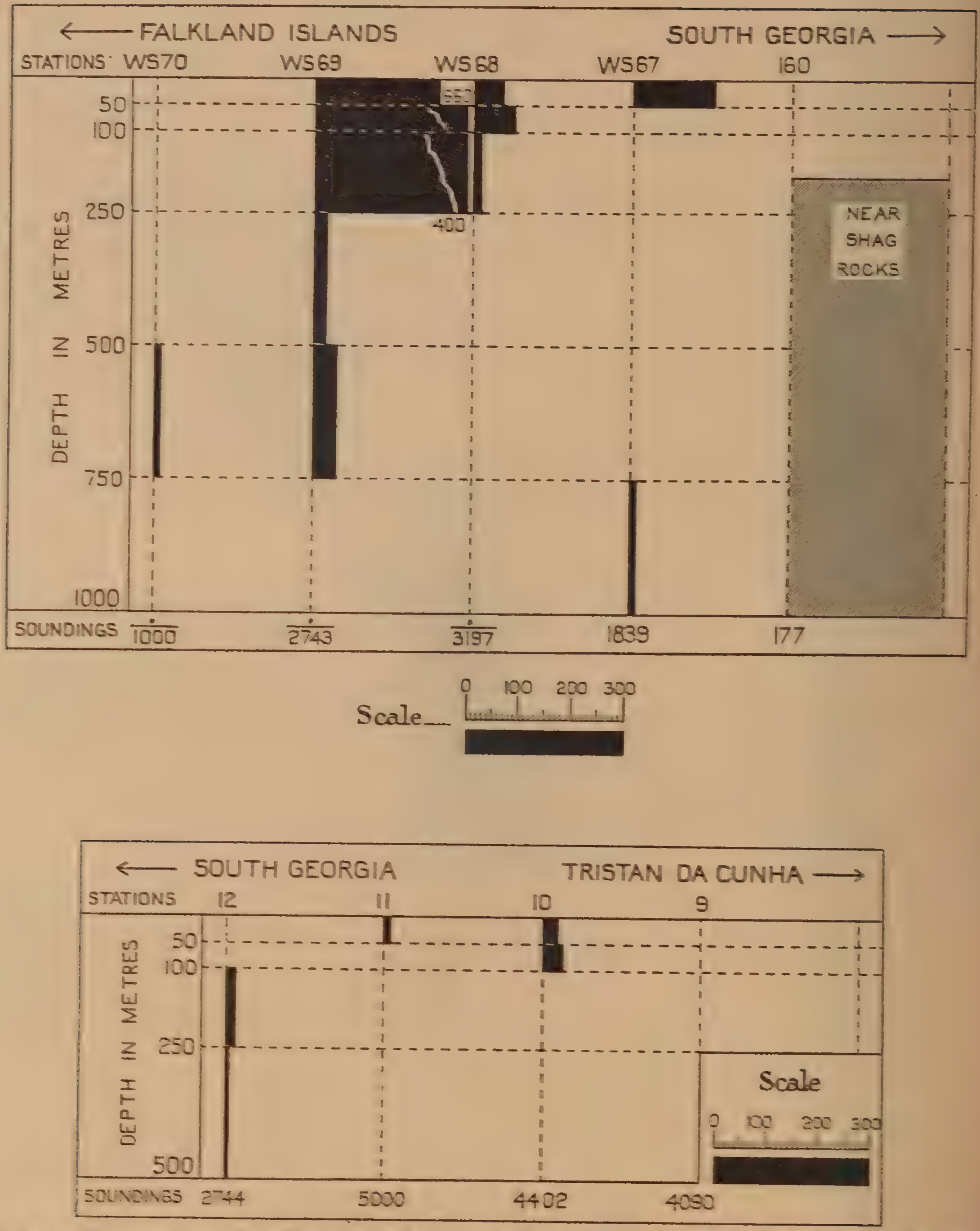


Fig. 44. Showing the vertical distribution of Foraminifera at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.

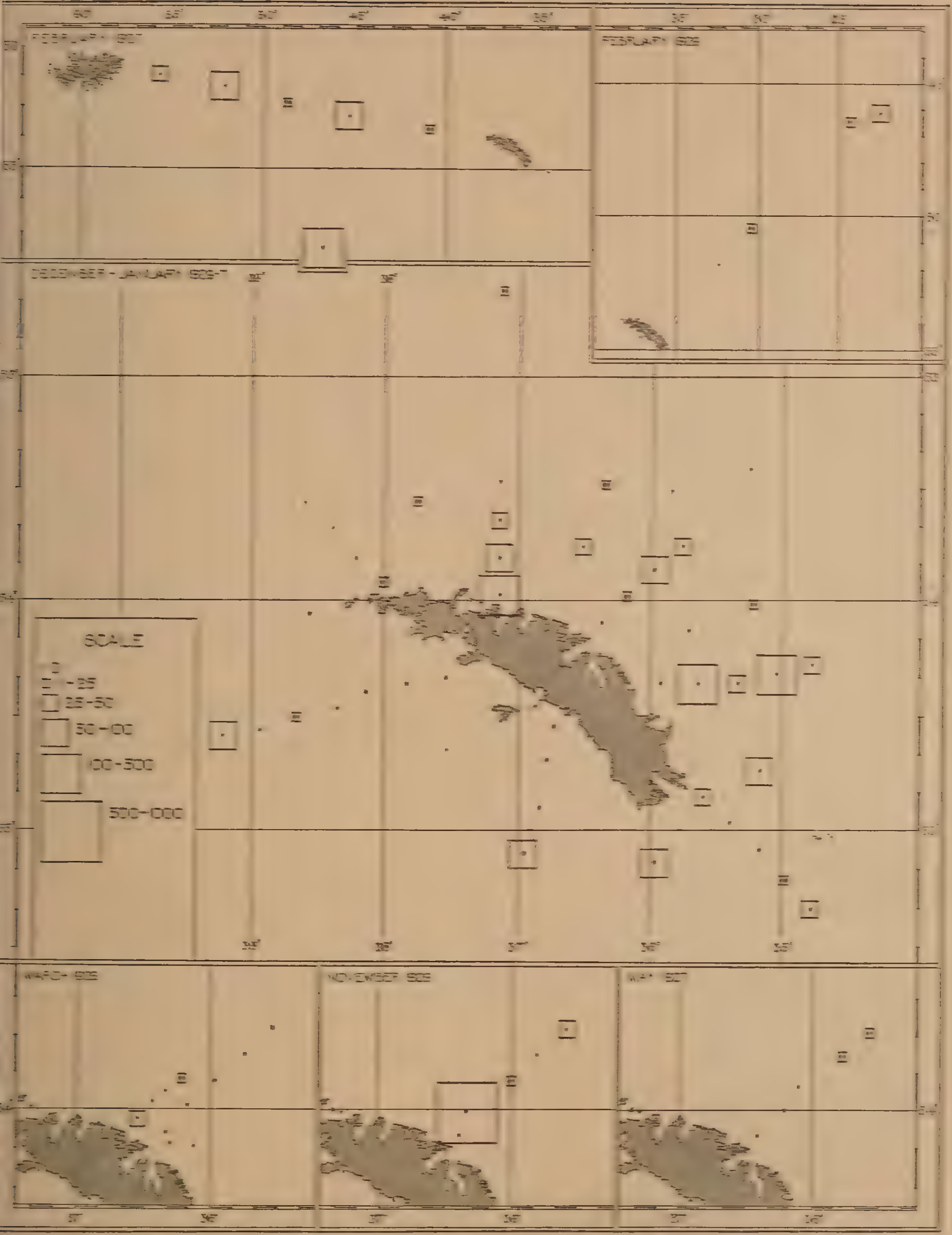
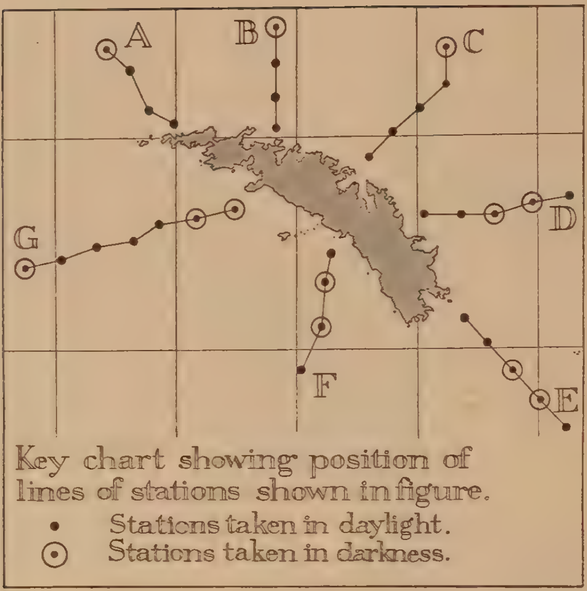

FEBRUARY 1927
FEBRUARY 1929
DECEMBER-JANUARY 1926-7
SCALE
0
1-25
25-50
50-100
100-500
500-1000
MARCH 1929
NOVEMBER 1929
MAY 1927

Fig. 45. Charts showing the distribution of Radiolaria in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.


A
B
C
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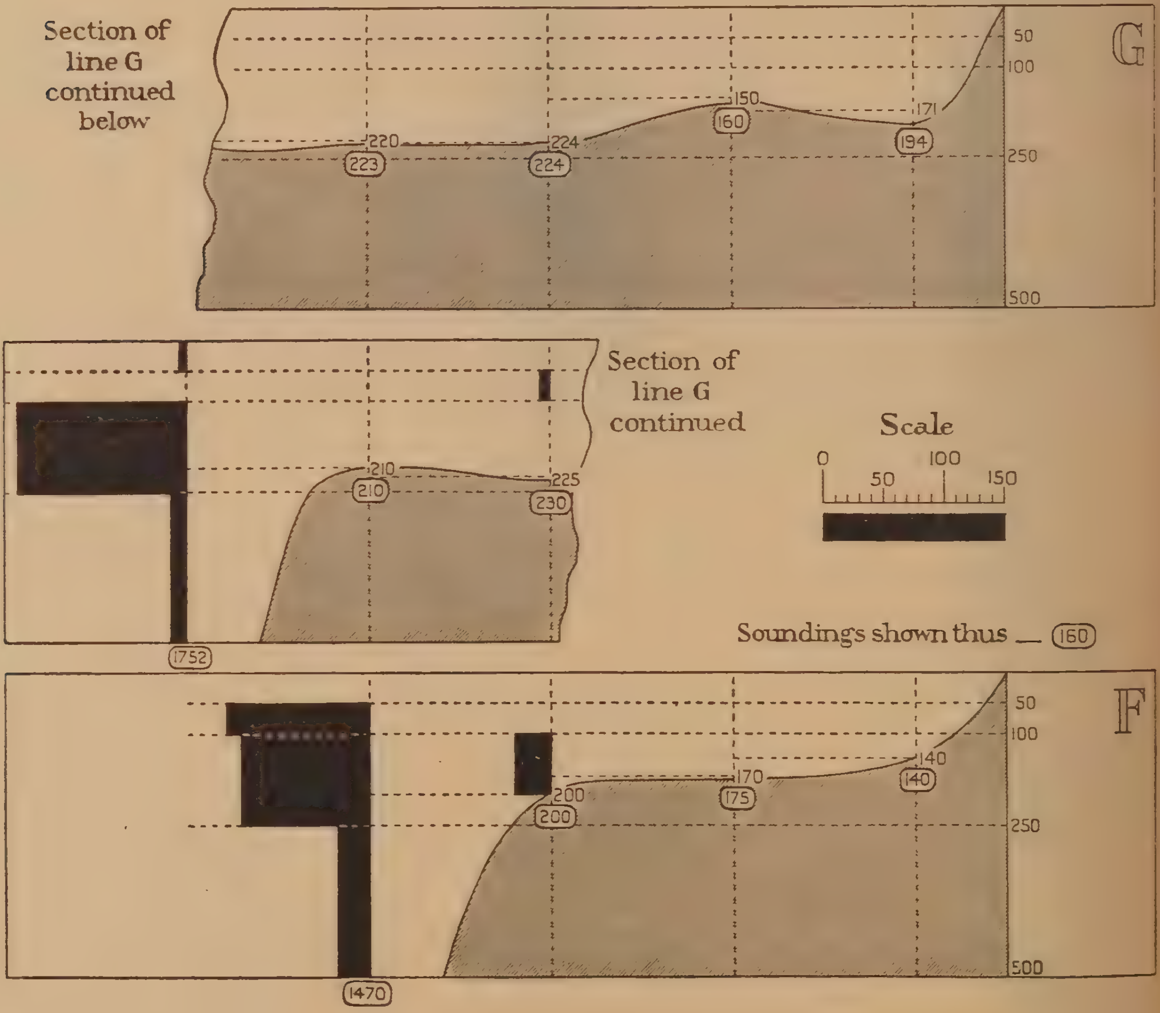
G
Key chart showing position of lines of stations shown in figure.
• Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 46. Showing the vertical distribution of

Radiolaria

down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



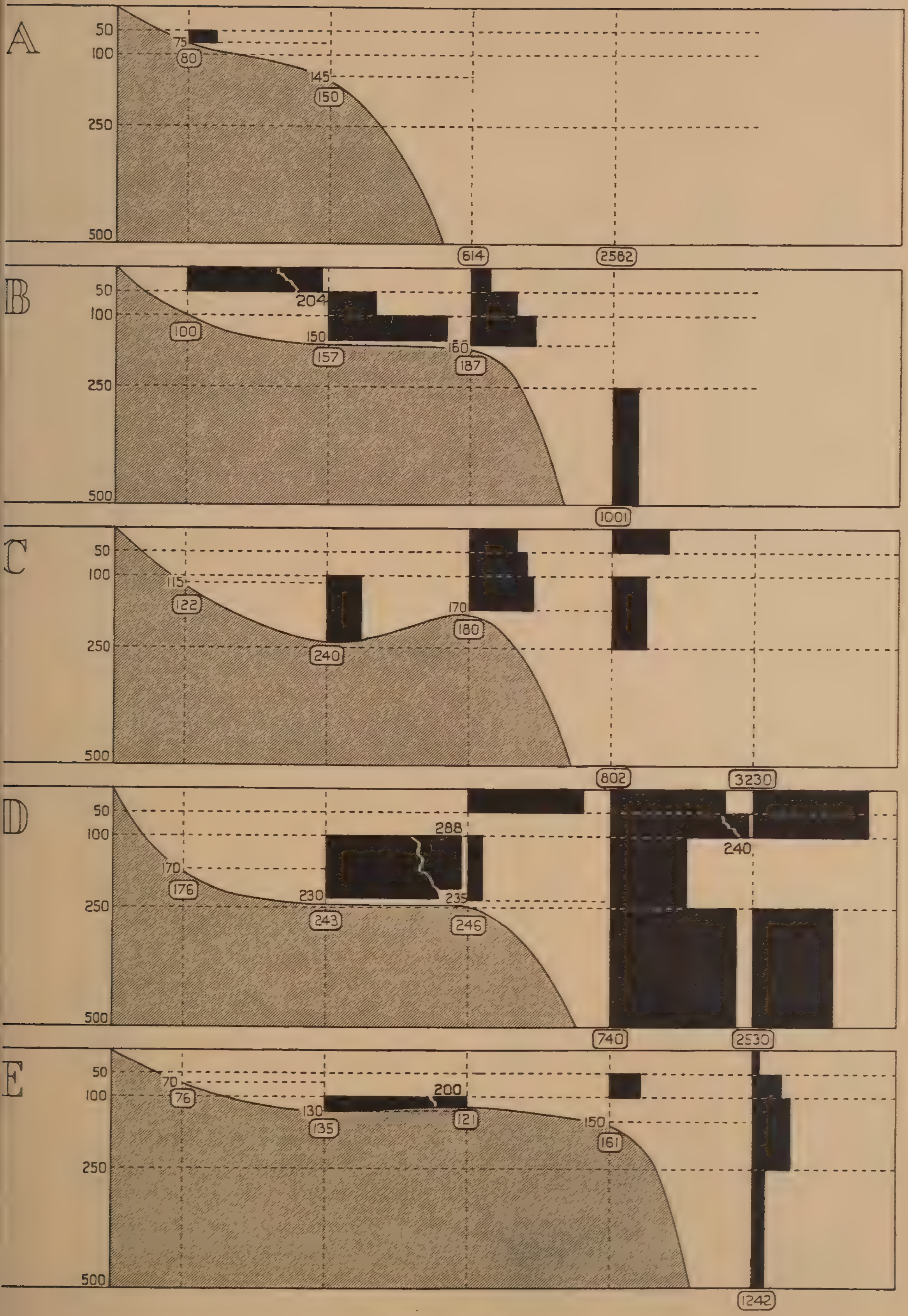
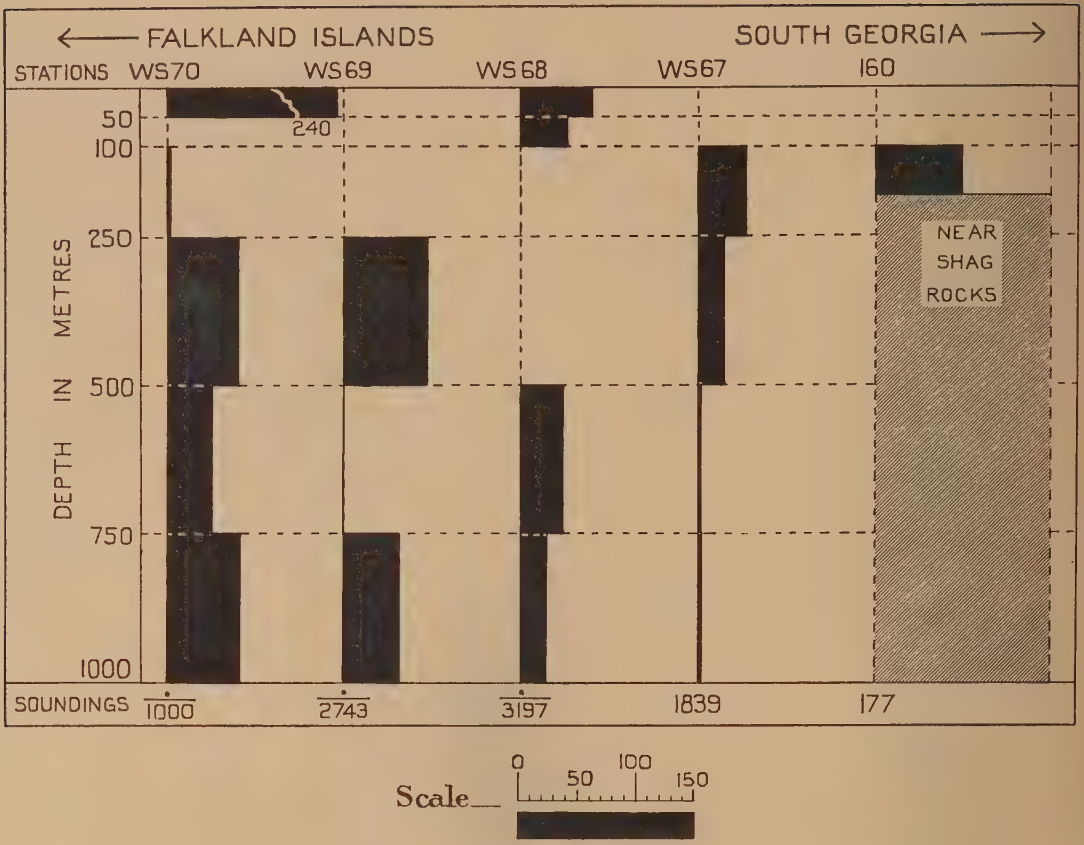


Fig. 46—*continued*



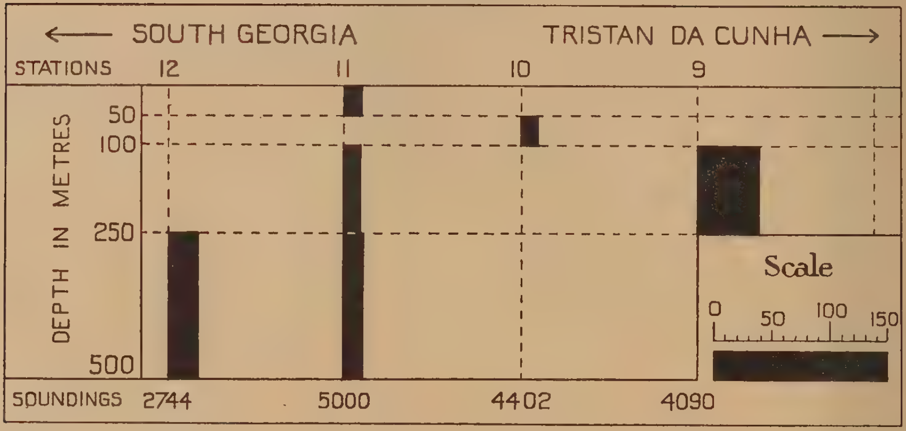


Fig. 47. Showing the vertical distribution of Radiolaria at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.

Tintinnidae

Our knowledge of the distribution of the Tintinnidae is obtained from the N 50 V nets hauled from 100 m. to the surface. Little information is available from the stations to the east of South Georgia taken in March 1926, when the N 50 V net was used on only three occasions, yielding none at Sts. 23 and 31, but 3300 at St. 41 C.

The distribution round South Georgia during the December-January survey, 1926–7, is shown in Fig. 48, where it will be seen that they occurred on the western side of the island in somewhat larger numbers than on the eastern side. A large number, 192,000, was taken at St. 161 far to the south-west of the island; on the line to the Falkland Islands taken at the same time, in February 1927, the number decreased until none were met with at Sts. WS 69 and WS 70 across the line of Antarctic Convergence; this is shown in Fig. 48. A complete statement of the numbers taken is shown in Appendix II, where it will be seen that fair numbers were taken in May 1927, to the east of South Georgia at Sts. WS 110–114.

COELENTERATA

The distribution of the medusae and Siphonophora in general is tabulated in Appendix II. Mr E. T. Browne has kindly identified some of the more important medusae and Captain A. K. Totton likewise the Siphonophora.

The distribution of these forms is as follows:

Anthomedusae

Catablema weldoni, E. T. Browne.

St. 133 ... 2 at 100 m.
St. 138 ... 1 at 77 mm.
St. WS 22 ... 1 at 185 m.
St. WS 29 ... 1 at 131 m.

Five specimens of this medusa were taken by the Gauss[1] Expedition at their winter station, approx. 66° S, 90° E.

Sibogita borchgrevinki, E. T. Browne.

St. WS 20 ... 3 at 90 m.
St. WS 37 ... 1 at 250–100 m.
St. WS 42 ... 1 at 0–5 m.

This species was taken by both the Southern Cross[2] and Gauss[1] Expeditions.

Leptomedusae

Cosmetirella sp.

St. 41 B ... 1 at 265–150 m.

C. simplex was the commonest Leptomedusan taken by the Gauss[1] and was also taken by the Southern Cross[2] and National Antarctic (Discovery)[3] Expeditions.

Narcomedusae

Pegantha sp.

St. WS 29 ... 1 at 80 m.

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[1] Vanhöffen (1912).

[2] Smith (1902).

[3] Browne (1910).

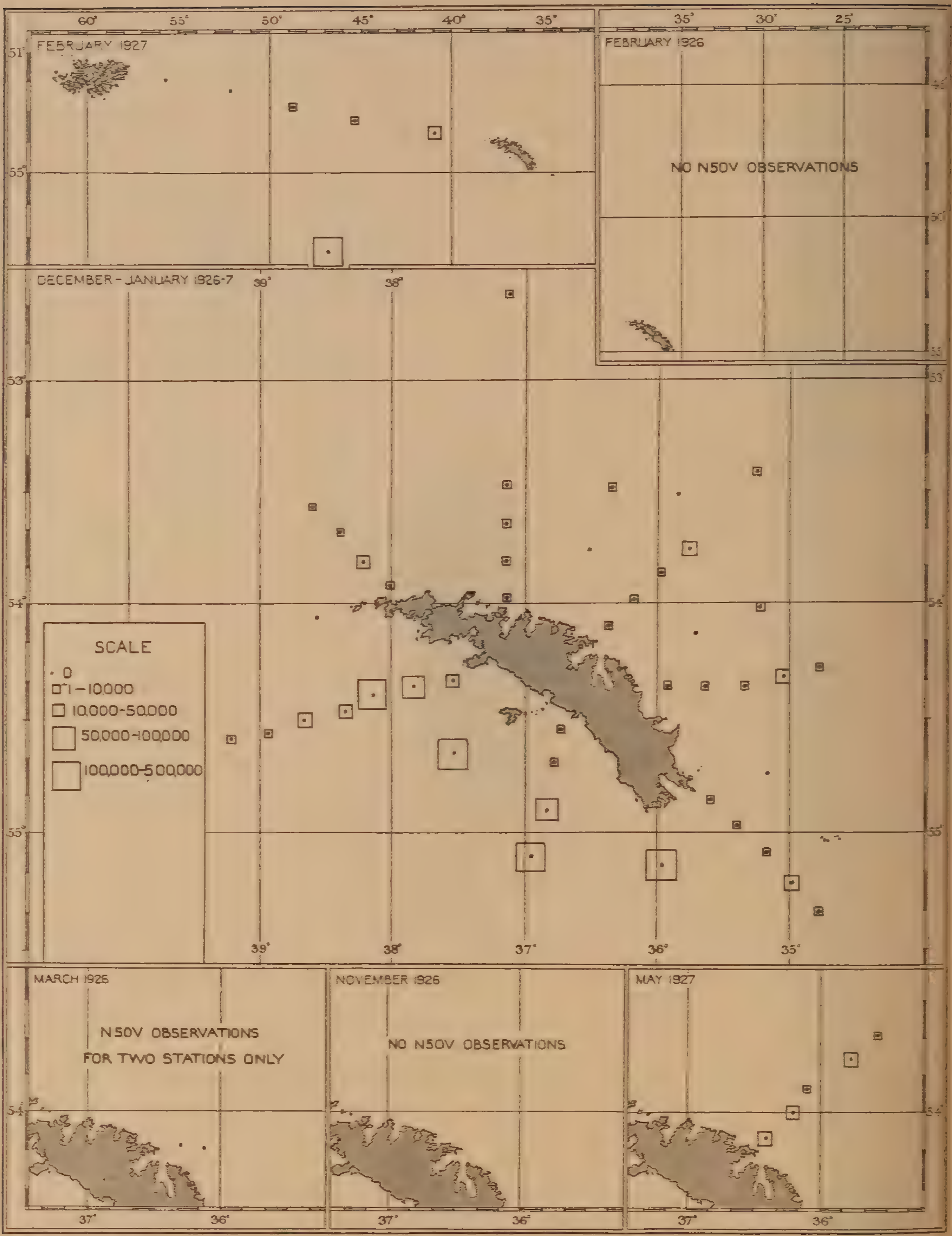
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1927
35°
30°
25°
FEBRUARY 1926
NO N50V OBSERVATIONS
DECEMBER - JANUARY 1926-7
39°
38°
53°
54°
55°
37°
36°
35°
SCALE
· 0
1–10,000
10,000–50,000
50,000–100,000
100,000–500,000
MARCH 1926
N50V OBSERVATIONS
FOR TWO STATIONS ONLY
NOVEMBER 1926
NO N50V OBSERVATIONS
MAY 1927
54°
37°
36°

Fig. 48. Chart showing the distribution of Tintinnidae in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per vertical haul with the N 50 V net from 100–0 m. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

P. trilobosa was taken by the 'Gauss'.[1]

Solmundella sp.

St. WS 17 ...	1 at 50–0 m.
St. WS 17 ...	2 at 250–100 m.
St. 138	10 at 2000–1000 m.
St. 151	1 at 250–100 m.
St. WS 30 ...	8 at 67 m.
St. WS 44 ...	1 at 200–100 m. 1 at 750–500 m.
St. 54	1 at 250–100 m.
St. 67	1 at 750–500 m.
St. 68	1 at 750–500 m.
St. WS 69 ...	2 at 500–250 m. 1 at 750–500 m.
St. 70	1 at 1000–750 m.

Solmundella was the commonest medusa taken in the Antarctic both by the National Antarctic (Discovery)[2] and Gauss[1] Expeditions. It was also taken by the 'Southern Cross'[3] and 'Belgica'[4]; and by the 'Française'[5] at the Falkland Islands.

Trachymedusae

Botrynema brucei, E. T. Browne.

St. WS 63 ... 2 at 1000–750 m.

This species was taken both by the 'Scotia'[6] and the 'Gauss'.[1]

Homoeonema sp.

St. 129	1 at 500–250 m.
St. 151	1 at 250–100 m.
St. WS 22 ...	2 at 1000–750 m. 1 at 1000–0 m.
St. WS 29 ...	2 at 250–100 m. 1 at 500–250 m.
St. WS 36 ...	1 at 750–500 m.
St. WS 38 ...	1 at 1000–750 m.
St. WS 54 ...	1 at 500–250 m.
St. WS 67 ...	2 at 1000–750 m.
St. WS 67 ...	3 at 1000–300 m.
St. WS 70 ...	1 at 500–250 m.
St. WS 110 ...	1 at 1000–750 m.

It is seen that in many instances these forms occurred in the warmer intermediate layer, i.e. 1000–750 m., and never in the purely Antarctic surface water, although at times in a mixture of the two.

The only previous record of this genus in the Antarctic appears to be the single specimen of *H. racovitzae* taken by the 'Belgica'[4] in 70° 09′ S. 82° 35′ W.

Trachynemidae.

St. 125	1 at 1000–750 m.
St. WS 70 ...	2 at 1000–750 m.

In the former case in the warmer intermediate water and in the latter in a mixture of this and the sub-Antarctic surface water.

Siphonophora

Chuniphyes multidentata, Leres and Van Riemsdigk.

St. WS 63 ... 3 at 1000–750 m.

This is in the warm intermediate water, possibly of Pacific origin (see footnote, p. 8). It was taken by the 'Albatross' in the east tropical Pacific. It has not been taken in the Antarctic Zone before.

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[1] Vanhöffen (1912).
[2] Browne (1910).
[3] Smith (1902).
[4] Maas (1906).
[5] Maas (1908).
[6] Browne (1908).

Crystallophyes amygdalina, Moser.

St. WS 36 ... 1 at 750–500 m.
St. WS 38 ... 5 at 500–250 m.
St. WS 38 ... 1 at 750–500 m.
St. WS 67 ... 1? at 500–250 m.

This species was taken in the Antarctic by the 'Gauss'.[1]

Dimophyes arctica (Chun).

St. 11 ... ... 1 at 500–250 m.
St. 131 ... ... 1 at 230–100 m.
St. 137 ... ... 2 at 700–500 m.
St. 138 ... ... 2 at 500–250 m.
1 at 750–500 m.
St. 151 ... ... 3 at 250–100 m.
2 at 750–500 m.
St. WS 22 ... 2 at 1000–750 m.
St. WS 26 ... 2 at 500–250 m.
3 at 750–0 m.
2 at 750–500 m.
St. WS 29 ... 2 at 250–1000 m.
St. WS 29 ... 1 at 500–250 m.
St. WS 30 ... 4 at 250–100 m.
St. WS 36 ... 5 at 750–500 m.
St. WS 44 ... 1 at 250–100 m.
St. WS 54 ... 5 at 500–250 m.
St. WS 67 ... 2 at 250–100 m.
St. WS 69 ... 2 at 500–250 m.
St. WS 70 ... 2 at 250–100 m.
4 at 500–250 m.
St. WS 110 ... 1 at 500–300 m.
St. WS 111 ... 1 at 500–250 m.

It is seen to occur in a mixture of the Antarctic surface water and the warmer intermediate layer. It was taken in fifty-two samples in the Antarctic by the 'Gauss'.[1]

Diphyes antarctica, Moser.

St. WS 38 ... 2 at 750–500 m.
St. WS 67 ... 3 at 1000–300 m.

This species was taken in fifty-five samples from the Antarctic by the 'Gauss'.[1]

Galeolaria truncata (Sars).

St. WS 70 ... 1 at 750–500 m.

This station is in the sub-Antarctic Zone. But a single specimen was taken in the Antarctic by the 'Gauss'.[1]

Hippopodius serratus ?, Moser.

St. 151 ... ... 5 at 500–265 m.

It was taken by the 'Gauss'[1] on four occasions in the Antarctic.

Praya cymbiformis (Delle Chiajé).

St. WS 54 ... 1 at 750–500 m.
St. WS 111 ... 2 at 500–250 m.

This cosmopolitan species has not been recorded from the Antarctic before.

Praya diphyes, Vogt.

St. WS 54 ... 1 at 500–250 m.
St. WS 68 ... 1 at 50–0 m.
St. WS 69 ... 2? at 750–500 m.
St. WS 110 ... 2 at 1000–750 m.
St. WS 111 ... 2? at 500–250 m.

Not recorded from the Antarctic before.

Pyrostephos vanhoffeni, Moser.

St. 17 ... ... 1 at 250–100 m.
St. 131 ... ... 41 (fragments) at 230–100 m.
St. 137 ... ... 1 at 100–50 m.
St. 139 ... ... 1 at 250–170 m.
St. 151 ... ... 2 at 250–100 m.
St. WS 18 ... 1 at 100–0 m.
St. WS 26 ... 1 at 750–0 m.
St. WS 29 ... 1 at 250–100 m.
St. WS 35 ... 1 at 50–0 m.
8 at 150–100 m.
St. WS 38 ... 1 at 50–0 m.
St. WS 63 ... 4 at 750–500 m.

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[1] Moser (1925).

It was taken in twenty-eight samples from the Antarctic by the 'Gauss'.[1]

Thalassophyes crystallina, Moser.

St. WS 36 ... 1 at 750–500 m.

Taken in 66° S by the 'Gauss'.[1]

CTENOPHORA

The general distribution of the Ctenophora is tabulated in Appendix II. They were not taken in large numbers except in March and April 1926, to the east of South Georgia, when *Beroë* formed an important part of the plankton near to the coast. In the same area in November and December 1926, and in May 1927, only small numbers were taken. The rapidity with which the operations at sea were necessarily carried out in order to complete the survey while suitable weather conditions lasted often prevented the examination of the plankton on the spot, and when examined after a considerable interval of time the frail Ctenophora had often disintegrated so that they could only be recognized as such, further identification being impossible. The majority of those unidentified belonged to *Pleurobrachia*.

Beroë and *Pleurobrachia* were both taken in the Antarctic by the 'Gauss'.[2]

NEMERTINEA

A single specimen of *Pelagonemertes* sp. was taken at St. WS 22 at a depth of 1000–750 m., i.e. in the warmer intermediate layer, probably of Pacific origin. It has not previously been recorded in the Antarctic Zone.

CHAETOGNATHA

The Chaetognatha were examined by Dr H. F. Bargmann who found the following four species:

Eukrohnia hamata (Möbius).
Sagitta maxima (Conant).
Sagitta planktonis, Steinhaus.
S. gazellae, Ritter-Záhony.

Eukrohnia hamata was predominant, and was present at nearly all stations, including those approaching South Georgia from Tristan da Cunha (Sts. 9–12) and those between South Georgia and the Falkland Islands (Sts. WS 67–70), it being equally common on each side of the line of the Antarctic Convergence. It was taken in the N 70 V, N 70 H and N 100 H nets. Its vertical distribution, as sampled with the N 70 V nets, is shown in Fig. 49. Fig. 50 shows the distribution round South Georgia during the December–January survey, 1926–7, and also enables one to compare the numbers present on the same line—the C line—at four different seasons, viz. March 1926, November 1926, December 1926 and May 1927. It is remarkably constant in its numbers throughout the area and at these different seasons. It is most abundant at depths between 250 and 50 m., i.e. in a mixture of the cold Antarctic surface water and that of the warmer water below. Table XVI shows its average depth distribution as shown by the N 70 V nets. Fig. 51 also shows its distribution on the lines approaching

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[1] Moser (1925).

[2] Moser (1909).

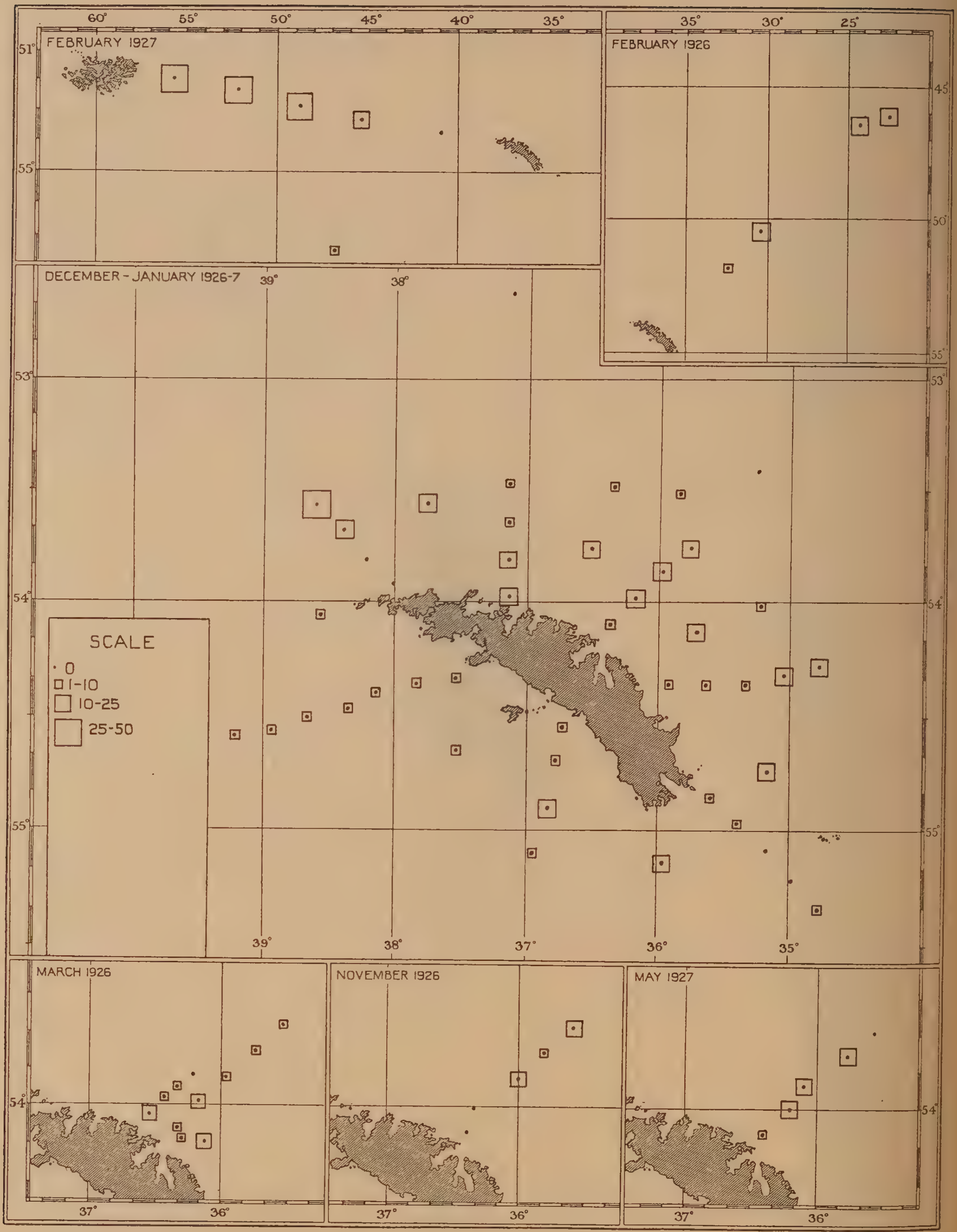
FEBRUARY 1927
FEBRUARY 1926
DECEMBER - JANUARY 1926-7
MARCH 1926
NOVEMBER 1926
MAY 1927
SCALE
· 0
□ 1-10
□ 10-25
□ 25-50
60°
55°
50°
45°
40°
35°
30°
25°
51°
53°
54°
55°
45°
50°
39°
38°
37°
36°

Fig. 49. Charts showing the distribution of *Eukrohnia hamata* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

South Georgia from Tristan da Cunha, and between South Georgia and the Falkland Islands. The complete details of its occurrence are given in Appendix II.

E. hamata was taken in the Antarctic by the 'Challenger',[1] National Antarctic ('Discovery'),[2] 'Gauss',[3] 'Scotia'[4] and 'Aurora'.[5] It occurs also in Arctic waters and is a mesoplanktonic form in warmer latitudes.

Sagitta gazellae, *S. maxima* and *S. planktonis*. All three species had a general distribution, but none of them was abundant. Of the three, *S. gazellae* was most frequently met with. Their occurrence is tabulated in Appendix II. Their depth distribution is shown in Tables XVII, XVIII and XIX. All three have been recorded in the Antarctic by the 'Gauss',[3] 'Scotia'[4] and 'Terra Nova'[6] and *S. gazellae* and *S. planktonis* by the 'Aurora'.[5]

Table XVI

The depth distribution of Eukrohnia hamata *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	160	84	38·1
100–50	803	81	198·3
250–100	1336	33	269·9
500–250	1120	29	154·5
750–500	416	21	79·2
1000–750	258	17	60·7

Table XVII

The depth distribution of Sagitta planktonis *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	0	84	0
100–50	0	81	0
250–100	8	33	1·6
500–250	45	29	6·2
750–500	33	21	6·3
1000–750	10	17	3·3

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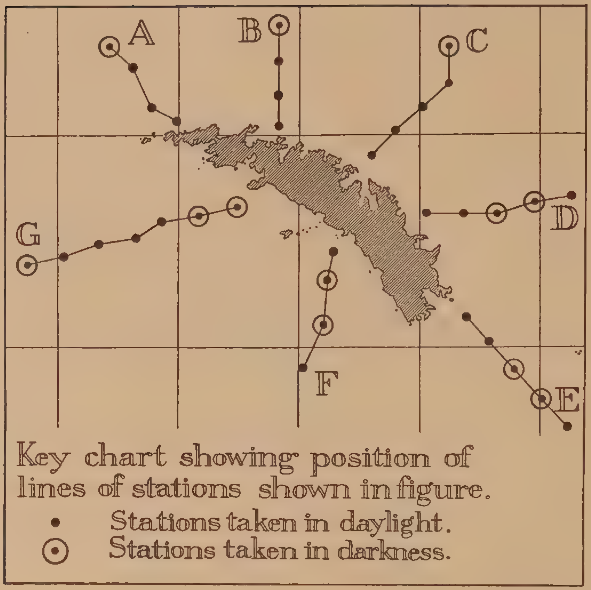
[1] Fowler (1907).
[2] Fowler (*ibid.*).
[3] Ritter-Záhony (1911).
[4] Jameson (1914).
[5] Johnston (1921).
[6] Burfield (1930).


A
B
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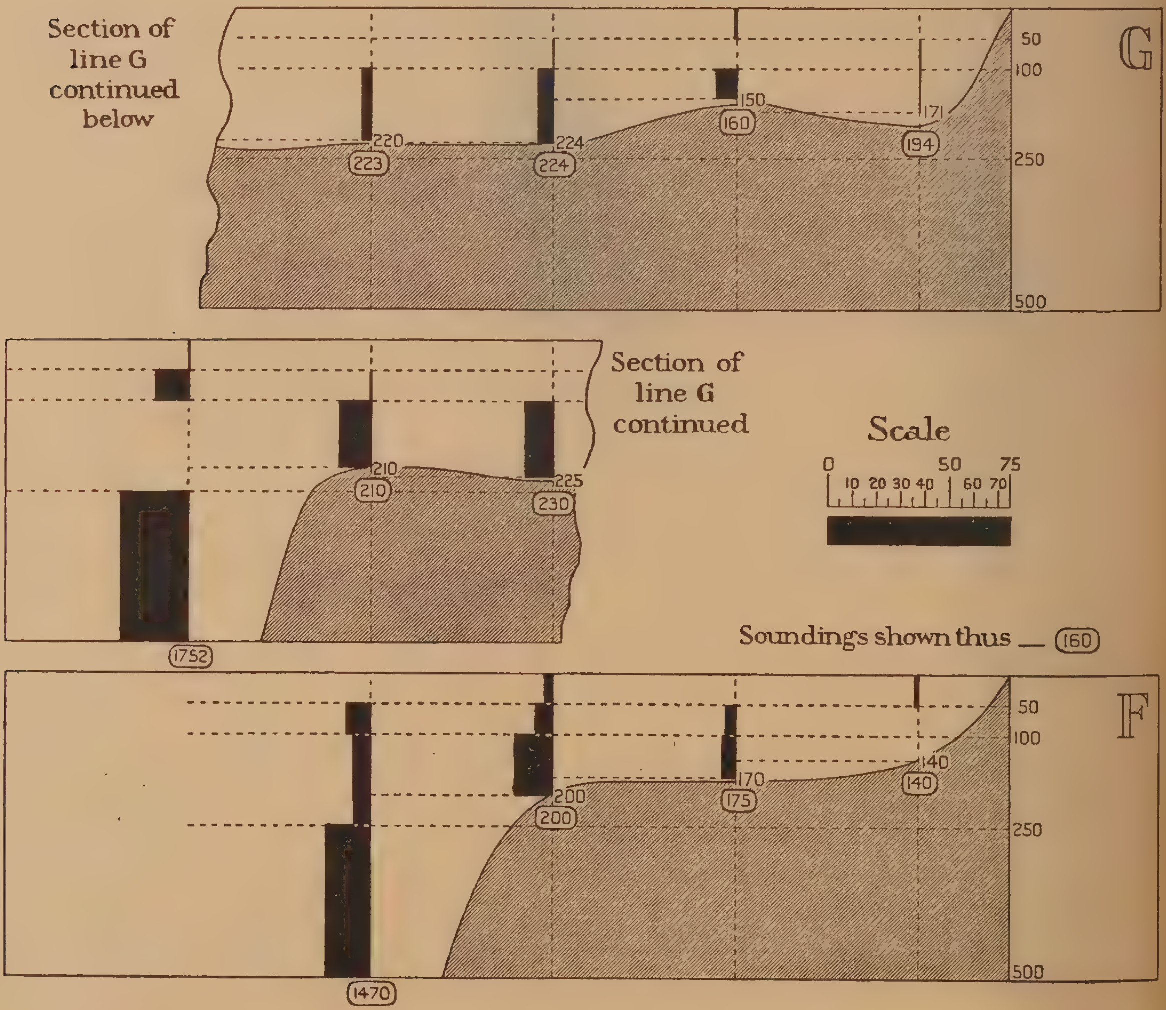
D
E
F
G
Key chart showing position of lines of stations shown in figure.
● Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 50. Showing the vertical distribution of **Eukrohnia hamata** (Möbius) down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



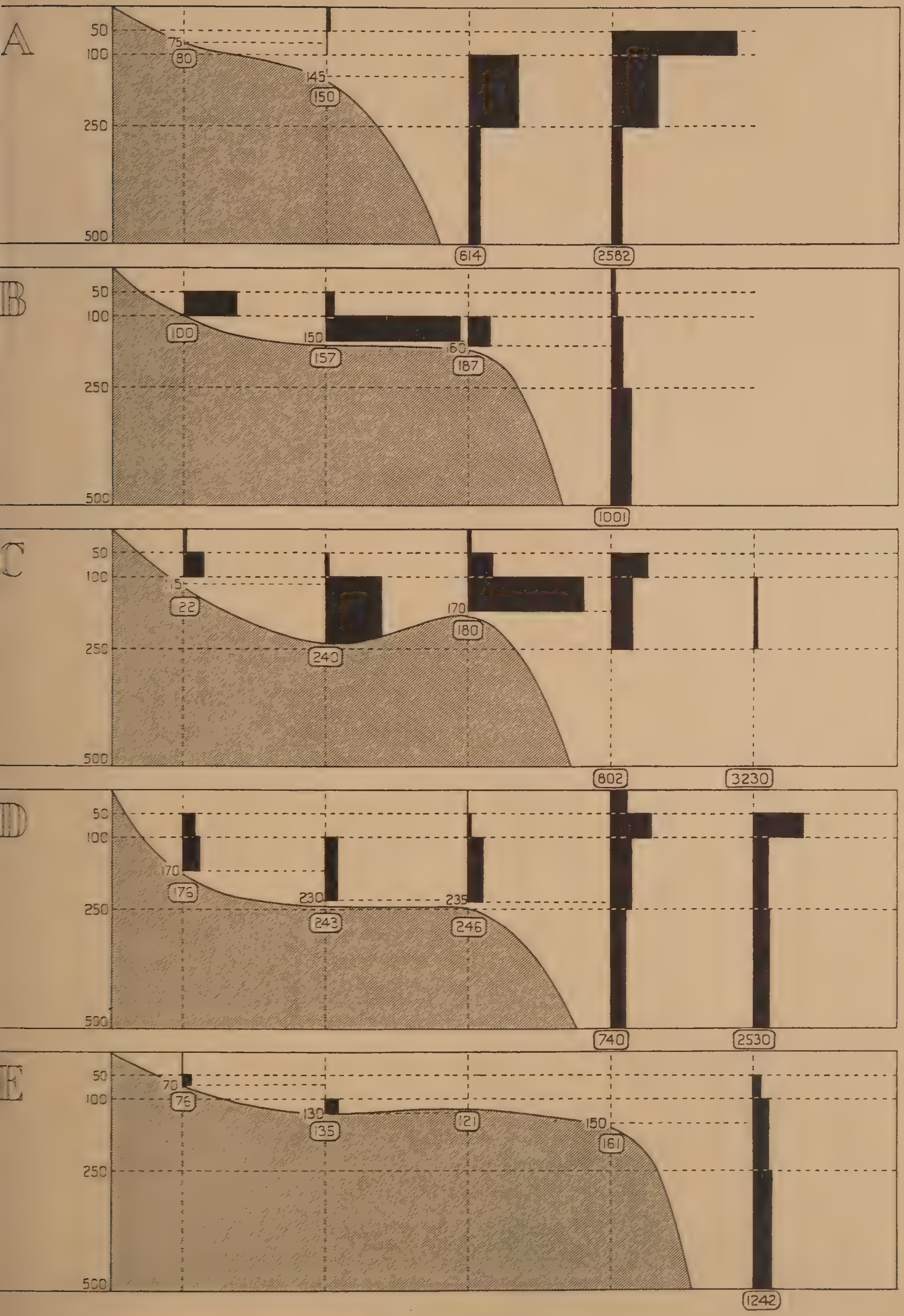
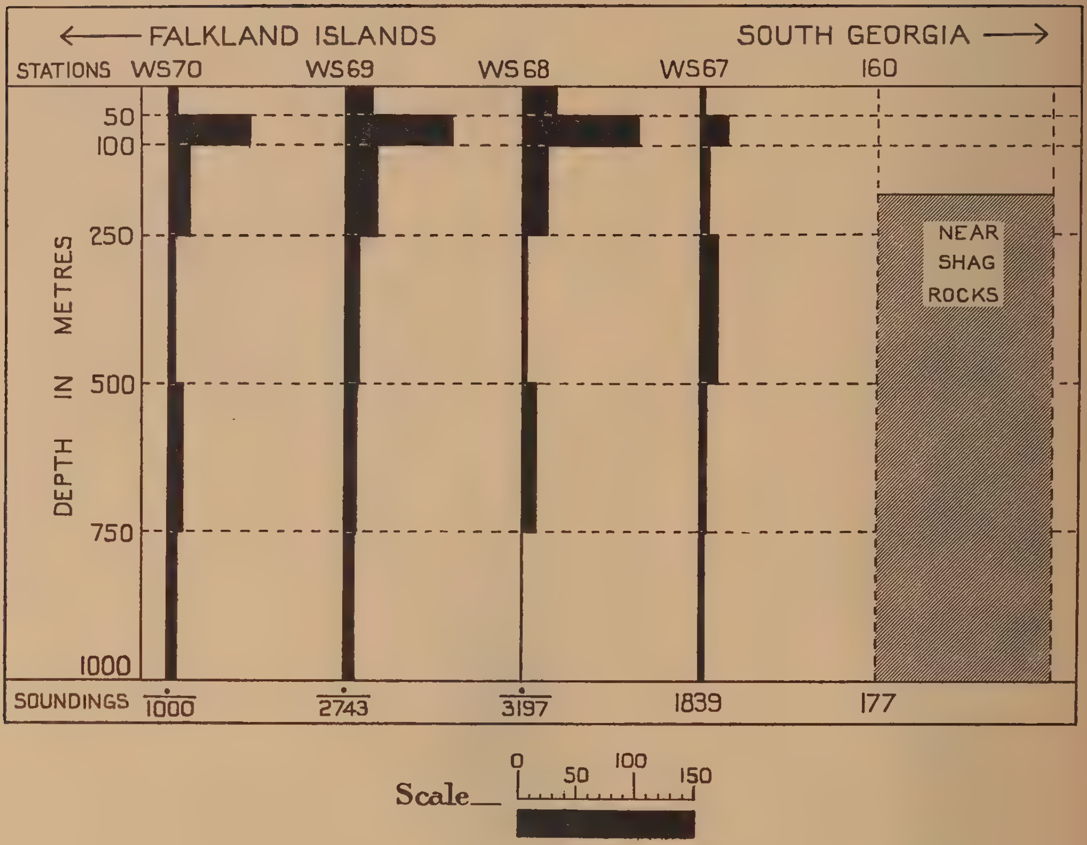


Fig. 50—*continued*



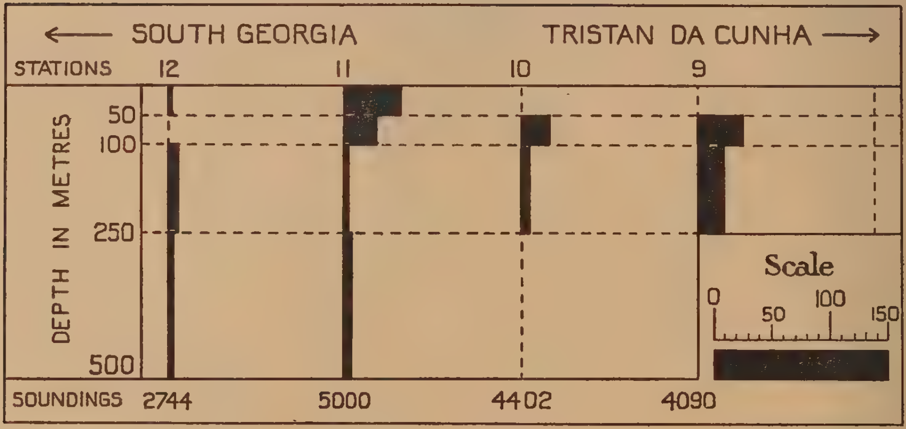


Fig. 51. Showing the vertical distribution of *Eukrohnia hamata* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.

Table XVIII

The depth distribution of Sagitta gazellae *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	8	84	1·9
100–50	23	81	5·7
250–100	33	33	6·6
500–250	25	29	3·5
750–500	13	21	2·5
1000–750	6	17	1·4

Table XIX

The depth distribution of Sagitta maxima *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	0	84	0
100–50	9	81	2·2
250–100	36	33	7·3
500–250	60	29	8·3
750–500	13	21	2·5
1000–750	14	17	3·2

POLYCHAETA

Of the planktonic Polychaeta *Pelagobia longicirrata*, Greeff, and species of *Tomopteris* were the outstanding forms.

Pelagobia longicirrata had a very general distribution throughout the area (Fig. 52); its numbers, together with those of young Polychaeta which in most instances were the young of *Pelagobia*, are recorded in Appendix II. It occurred in slightly larger numbers to the west of South Georgia than to the east. In depth it extended down to below 750 m., but was most abundant at levels between 250 and 50 m.

This species was taken on thirty-six occasions from below the ice at the winter quarters of the National Antarctic (Discovery)[1] Expedition, also in thirty-six plankton samples in the Antarctic by the 'Gauss'.[2] It is a cosmopolitan species.

Tomopteris had also a very general distribution but was rarely abundant.

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[1] Ehlers (1912).

[2] Ehlers (1913).

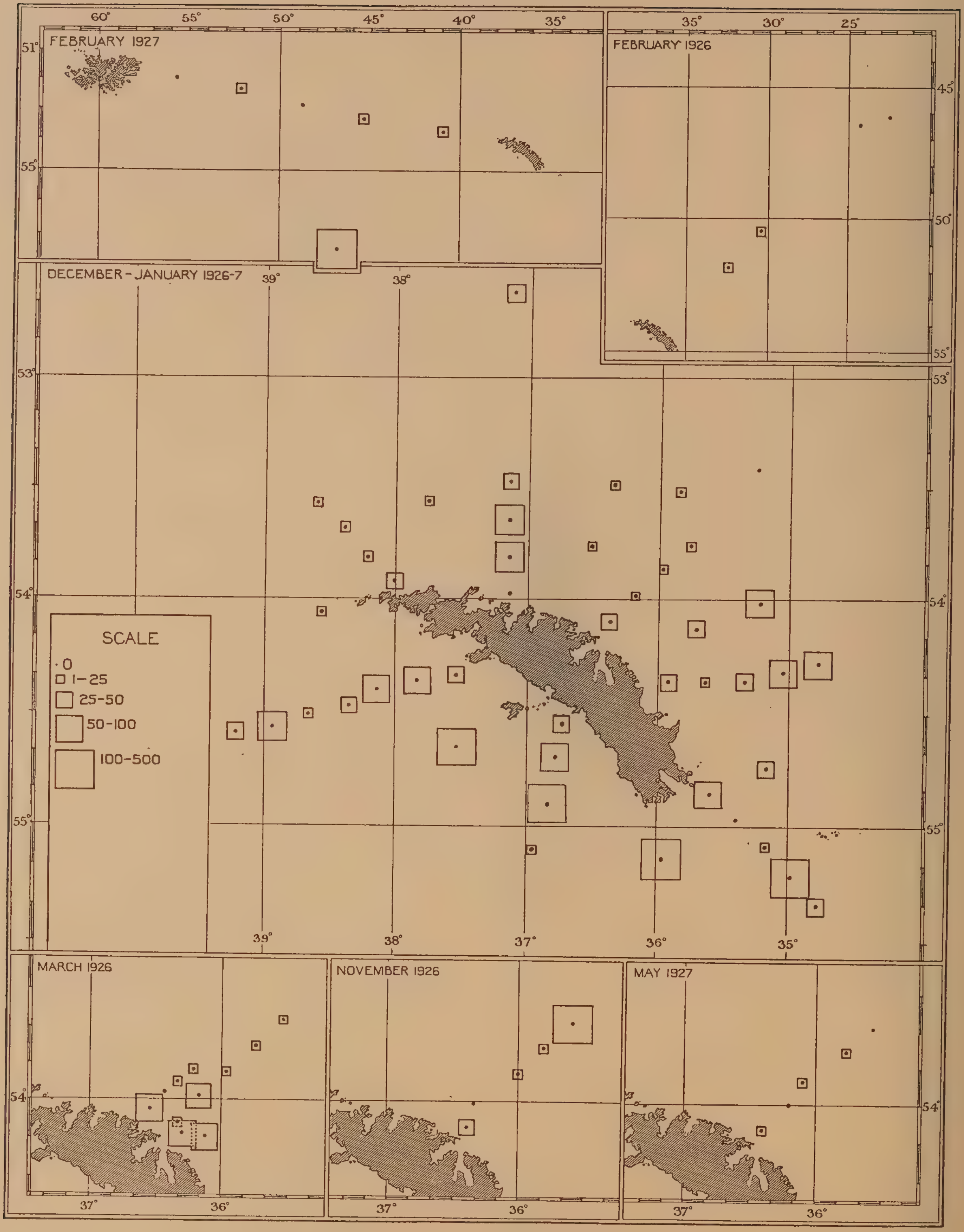
FEBRUARY 1927
FEBRUARY 1926
DECEMBER – JANUARY 1926-7
MARCH 1926
NOVEMBER 1926
MAY 1927
SCALE
· 0
1–25
25–50
50–100
100–500
60°
55°
50°
45°
40°
35°
30°
25°
51°
55°
45°
50°
53°
54°
39°
38°
37°
36°

Fig. 52. Charts showing the distribution of *Pelagobia* and young Polychaeta (mostly *Pelagobia*) in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

Tomopteris carpenteri, Quatrefages, was recorded in the following numbers:

St. 11	N 70 V	4 at	250–100 m.
St. 124	N 100 H	1 at	0–5 m.
St. 127	N 70 H	1 at	79 m.
St. 128	N 70 V	1 at	160–100 m.
St. 128	N 100 H	1 at	100 m.
St. 133	N 100 H	12 at	0–5 m.
		2 at	50 m.
		5 at	100 m.
St. 136	N 100 H	2 at	0–5 m.
St. 138	N 100 H	1 at	77 m.
		4 at	155 m.
St. 139	N 70 H	3 at	62 m.
St. 139	N 100 H	8 at	0–5 m.
		1 at	90 m.
St. 161	N 70 V	1 at	500–250 m.
St. WS 22	N 70 V	1 at	1000–750 m.
St. WS 22	N 100 H	2 at	82 m.
St. WS 26	N 100 H	1 at	96 m.
		2 at	192 m.
St. WS 29	N 100 H	2 at	118 m.
St. WS 35	N 100 H	6 at	0–5 m.
St. WS 36	N 70 V	2 at	750–500 m.
St. WS 38	N 100 H	4 at	106 m.
St. WS 39	N 100 H	1 at	87 m.
St. WS 40	N 100 H	1 at	72 m.
St. WS 41	N 100 H	1 at	146 m.
St. WS 42	N 100 H	1 at	0–5 m.
St. WS 44	N 100 H	8 at	64 m.
St. WS 45	N 100 H	1 at	0–5 m.
St. WS 47	N 100 H	4 at	0–5 m.
St. WS 54	N 70 V	1 at	500–250 m.

It is seen that whilst commonly it occurred in the true Antarctic surface layer it may also occasionally be found deep in the warmer intermediate layer. It was taken in the Ross Sea by the 'Terra Nova',[1] off Kaiser Wilhelm II by the 'Gauss'[2] and off Adélie Land by the 'Aurora'.[3]

Tomopteris septentrionalis, Quatrefages ex Steenstrup, was recorded only on the eastern side of South Georgia in water of Weddell Sea origin, as follows:

St. 130	N 100 H	1 at	77 m.
St. 137	N 100 H	2 at	132 m.
St. 137	N 70 H	32 at	120 m.
St. WS 20	N 100 H	2 at	190 m.
St. WS 21	N 100 H	2 at	192 m.
St. WS 22	N 100 H	1 at	82 m.
		1 at	185 m.
St. WS 54	N 70 V	1 at	500–250 m.

This species is taken at both poles and is in fact cosmopolitan. It has previously been taken in the Antarctic by the 'Terra Nova',[1] having found it abundant in the Ross Sea, by the 'Gauss'[2] and by the 'Aurora'.[3]

The remaining *Tomopteris* spp. were unidentified and their numbers are recorded in Appendix II.

A number of specimens of Polychaeta were taken in the deeper hauls with the N 70 V nets, as follows:

Harmothoë benthophila, var. *bimucronata*, Fausch.

St. WS 70 ... 1 at 1000–750 m.

In the deep water of the sub-Antarctic Zone, not an Antarctic species.

Maupasia caeca, Viguier.

St. WS 70 ... 1 at 750–100 m.

This species was taken in the Antarctic by the National Antarctic ('Discovery'),[4] 'Gauss'[2] and 'Terra Nova'.[1]

Phalacrophorus pictus, Greeff.

St. WS 63 ... 1 at 500–250 m.

This is the first time it is recorded from the Antarctic Zone.

---

[1] Benham (1929).
[2] Ehlers (1913).
[3] Benham (1921).
[4] Ehlers (1912).

Table XX

The depth distribution of Pelagobia longicirrata *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	459	80	109·3
100–50	1828	81	451·3
250–100	1088	33	219·8
500–250	102	29	14·1
750–500	164	21	31·2
1000–750	351 (131)*	17	82·6 (30·8)*

* Omitting one exceptionally heavy catch of 220.

Sagitella cornuta, Ehlers.

St. 125 ... ... 2 at 500–250 m.
St. 137 ... ... 1 at 500–250 m.
St. WS 26 ... 2 at 750–0 m.
St. WS 30 ... 1 at 250–100 m.
St. WS 38 ... 1? at 1000–750 m.
St. WS 67 ... 4 at 1000–300 m.
St. WS 70 ... 1 at 750–500 m.
1 at 1000–750 m.

Sagitella kowalevskii?.

St. WS 44 ... 1 at 750–500 m.

Taken by the National Antarctic ('Discovery')[1] and the 'Terra Nova'[2] in the Ross Sea.

Travisiopsis sp.

St. 151 ... ... 1 at 1000–750 m.
St. WS 110 ... 1 at 1000–750 m.

This genus has not been recorded in the Antarctic Zone before, and here the two examples are from the warmer intermediate layer.

Typhloscolex sp.

St. 137 ... ... 1 at 500–250 m.
St. WS 38 ... 4 at 500–250 m.
3 at 750–500 m.
St. WS 63 ... 2 at 500–250 m.
1 at 750–500 m.

Typhloscolex mulleri, Busch.

St. 129 ... ... 1 at 500–250 m.
St. 161 ... ... 2 at 500–250 m.
St. WS 26 ... 3 at 500–250 m.
1 at 750–500 m.
St. WS 29 ... 1 at 250–100 m.
1 at 500–250 m.
St. WS 30 ... 1 at 500–250 m.
2 at 750–500 m.
St. WS 36 ... 1 at 500–250 m.
St. WS 38 ... 1? at 1000–750 m.
St. WS 39 ... 1 at 230–100 m.
St. WS 43 ... 1 at 700–100 m.
St. WS 61 ... 1 at 500–250 m.
St. WS 68 ... 2 at 750–500 m.

This cosmopolitan species was taken in the Antarctic on ten occasions by the 'Gauss'.[3]

---

[1] Ehlers (1912).
[2] Benham (1929).
[3] Ehlers (1913).

Alciopid larvae were taken as follows:

St. 124	1 at	210–100 m.
St. WS 35 ...	1 at	51 m.
St. WS 36 ...	1 at	250–100 m.
St. WS 67 ...	1 at	250–100 m.
St. WS 112 ...	1 at	160–50 m.

CRUSTACEA

Ostracoda

The Ostracoda which were kindly identified by Mr F. C. Fraser were represented by at least eight species of *Conchoecia*, nearly all occurring in or over deep water.

Conchoecia hettacra, Müller, was the most abundant. It was distributed evenly round South Georgia in the December–January survey, 1926–7, in the deeper water beyond the continental shelf, that is in the warmer intermediate layer. Its average depth distribution as shown by the N 70 V nets is shown in Table XXI. It was present to the east of South Georgia also in November 1926 and May 1917, but not in March 1926. It was present in small numbers between South Georgia and the Falkland Islands in February 1927. Its general distribution is tabulated in Appendix II. It has been recorded by the Belgica,[1] Gauss[2] and Terra Nova[3] Expeditions, and thus is circumpolar in distribution.

The distribution of the remaining species is as follows:

Conchoecia antipoda, Müller.

St. 125	3 at	950–500 m.
	5 at	1000–750 m.
St. 129	5 at	750–560 m.
	3 at	950–780 m.
St. 137	7 at	700–500 m.
St. 138	6 at	750–500 m.
	7 at	1000–750 m.
	5 at	2000–1000 m.
St. 151	3 at	750–500 m.
	1 at	1000–750 m.
St. 161	11 at	750–500 m.
St. WS 20 ...	1 at	500–250 m.
St. WS 22 ...	1 at	750–500 m.
	7 at	1000–750 m.
	1 at	1000–0 m.
	3 at	750–0 m.
St. WS 26 ...	6 at	750–500 m.
	8 at	1000–750 m.
St. WS 30 ...	11 at	500–330 m.
	3 at	500–250 m.
	5 at	750–500 m.
St. WS 36 ...	1 at	500–250 m.
	8 at	750–500 m.
	1 at	1000–750 m.
St. WS 38 ...	3 at	750–500 m.
	6 at	1000–750 m.
St. WS 44 ...	11 at	750–500 m.
	2 at	1000–750 m.
St. WS 61 ...	2 at	500–250 m.
	6 at	760–500 m.
	4 at	1000–750 m.
St. WS 63 ...	3 at	750–500 m.
St. WS 67 ...	3 at	750–500 m.
	10 at	1000–750 m.
St. WS 68 ...	1 at	750–500 m.
St. WS 69 ...	4 at	1000–750 m.
St. WS 110 ...	4 at	1000–750 m.
St. WS 111 ...	1 at	500–250 m.
	6 at	750–500 m.

This species is also circumpolar, having been taken in the Antarctic Zone by the 'Gauss'[2] and 'Terra Nova'.[3]

Conchoecia elegans, G. O. Sars.

St. WS 110 ...	1 at	500–300 m.
St. WS 111 ...	3 at	250–100 m.

This and the four next species are recorded from the Antarctic for the first time.

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[1] Müller (1906).

[2] Müller (1908).

[3] Barney (1921).

Conchoecia hyalophyllum, Claus.

St. 137	1 at	700–500 m.

Conchoecia obtusata, G. O. Sars.

St. WS 110 ...	1 at	250–100 m.

Conchoecia rotundata, Müller.

St. 137	1 at	700–500 m.

Conchoecia symmetrica, Müller.

St. 129	4 at	750–500 m.
	2 at	950–780 m.
St. 133	1 at	750–500 m.
St. 137	5 at	700–500 m.
St. 138	1 at	750–500 m.
St. 151	3 at	750–500 m.
St. 161	1 at	750–500 m.
	4 at	1000–750 m.
St. WS 22 ...	2 at	1000–0 m.
St. WS 26 ...	3 at	750–500 m.
	4 at	750–0 m.
St. WS 30 ...	1 at	500–250 m.
	2 at	750–500 m.
	1 at	1000–750 m.
St. WS 36 ...	5 at	750–500 m.
St. WS 38 ...	1 at	750–500 m.
	3 at	1000–750 m.
St. WS 44 ...	3 at	750–500 m.
	1 at	1000–750 m.
St. WS 61 ...	1 at	750–500 m.
	1 at	1000–750 m.
St. WS 63 ...	3 at	1000–750 m.
St. WS 67 ...	4 at	750–500 m.
St. WS 68 ...	2 at	750–500 m.
	4 at	1000–750 m.
St. WS 69 ...	5 at	750–500 m.
	2 at	1000–750 m.
St. WS 70 ...	3 at	500–250 m.
	7 at	750–500 m.
St. WS 110 ...	7 at	1000–750 m.
St. WS 111 ...	2 at	1000–750 m.

Table XXI

The depth distribution of Conchoecia hettacra *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	2	84	**0·5**
100–50	15	81	**3·7**
250–100	175	33	**32·3**
500–250	476	29	**65·6**
750–500	71	21	**13·5**
1000–750	24	17	**5·6**

Conchoecia spp.

St. 125	1 at	250–100 m.
	1 at	750–500 m.
St. 133	1 at	270–100 m.
	1 at	500–250 m.
	1 at	750–500 m.
St. 137	3 at	700–500 m.
St. 138	2 at	1000–750 m.
	1 at	2000–1000 m.
St. 151	4 at	750–500 m.
St. 160	4 at	100–50 m.
	5 at	180–100 m.
St. 161	3 at	500–250 m.
	1 at	750–500 m.
St. WS 20 ...	60 at	250–100 m.
St. WS 22 ...	1 at	50–0 m.
	120 at	500–250 m.
	1 at	750–500 m.
	1 at	1000–750 m.
St. WS 26 ...	1 at	500–250 m.
	2 at	750–500 m.
St. WS 29 ...	40 at	250–100 m.
St. WS 30 ...	1 at	500–250 m.

St. WS 30 ...	14 at	1000–750 m.
St. WS 37 ...	1 at	250–100 m.
St. WS 38 ...	1 at	1000–750 m.
St. WS 44 ...	1 at	500–250 m.
	80 at	750–500 m.
	2 at	1000–750 m.
St. WS 51 ...	2 at	200–100 m.
St. WS 63 ...	1 at	500–250 m.
	1 at	1000–750 m.
St. WS 67 ...	3 at	50–0 m.
	6 at	100–50 m.
	4 at	500–250 m.
St. WS 67 ...	10 at	750–500 m.
St. WS 68 ...	9 at	100–50 m.
	30 at	250–100 m.
	8 at	500–250 m.
	9 at	750–500 m.
	1 at	1000–750 m.
St. WS 69 ...	6 at	100–50 m.
	24 at	250–100 m.
St. WS 70 ...	1 at	100–50 m.
	7 at	250–100 m.
	1 at	750–500 m.
St. WS 113 ...	2 at	150–100 m.

Young Ostracoda unidentified are recorded in Appendix II.

Copepoda

The Copepoda, here as elsewhere, formed perhaps the most important element of the zooplankton. They were numerous both in species and individuals. We were very fortunate in having the services of the late Mr Andrew Scott, who identified them for us. He found 100 species in our collections: eighty-eight in the Gymnoplea and twelve in the Podoplea. Out of such a number, as is usually found to be the case, only a few may be regarded as really abundant, the following species being the more important in our survey:

Calanus simillimus, Giesbr.
C. propinquus, Brady.
C. acutus, Giesbr.
Rhincalanus gigas, Brady.
Clausocalanus laticeps, Farran.
Ctenocalanus vanus, Giesbr.
Drepanopus pectinatus, Brady.
Pareuchaeta antarctica, Giesbr.
Scolecithricella minor (Brady).
Pleuromamma robusta (F. Dahl).
Metridia gerlachei, Giesbr.
M. lucens, Boeck.
Oithona frigida, Giesbr.

Mr Scott found in the collection a new species of the genus *Candacia*. Notes of its occurrence are given under the genus, but unfortunately his untimely death intervened before he had drawn up a detailed description of the species for publication.

He records the following twenty-five species or genera from the Antarctic Zone for the first time:

Calanus minor, Claus.
Rhincalanus nasutus, Giesbr.
Clausocalanus furcatus (Brady).
Drepanopus pectinatus, Brady.
Spinocalanus horridus, Wolf.
Pseudochirella pustulifera, G. O. Sars.
Pareuchaeta scotti, Farran.
Onchocalanus cristatus, Wolf.
Cornucalanus magnus, Wolf.
Scolecithrix emarginata, Farran.
Scolecithricella minor (Brady).
Pleuromamma xiphias, Giesbr.
Metridia brevicauda, Giesbr.
Lucicutia magna, Wolf.
Disseta palumboi, Giesbr.
Haloptilus fons, Farran.
Augaptilus megalurus, Giesbr.
Centraugaptilus rattrayi, T. Scott.
Pachyptilus sp.
Phyllopus bidentatus, Brady.
P. ?helgae, Farran.
Bathypontia sp.
Mormonilla phasma, Giesbr.
Conaea rapax, Giesbr.
Lubbockia ?glacialis, Sars.

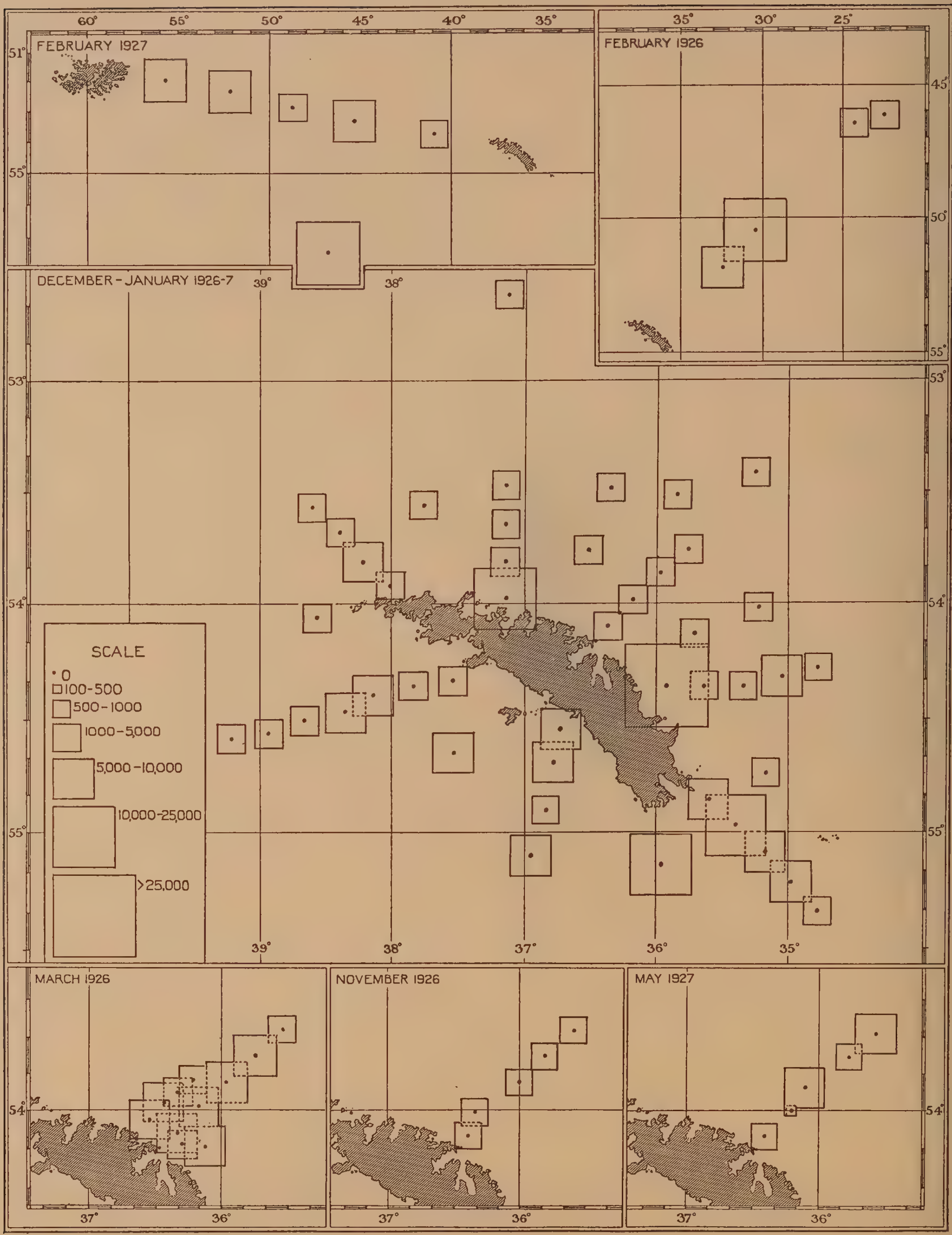
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
0
100-500
500-1000
1000-5,000
5,000-10,000
10,000-25,000
>25,000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 53. Charts showing the total Copepoda in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

Two of these species, *Drepanopus pectinatus*[1] and *Scolecithricella minor*, are of considerable importance in our region.

A fraction of every sample of the plankton was passed to Mr Scott, who made the detailed analyses of the Copepoda. In addition he analysed the N 70 H samples for Copepoda.

The N 70 H results have not been used in studying quantitatively the distribution of the different species. These samples were taken from only three horizontal layers which were intended to be approximately 0–5, 50 and 100 m. in depth; actually the depths and the speeds of tow sometimes varied considerably with different sea conditions (conditions often not ideal for oceanographical research). This being so, the N 70 H samples cannot give anything like so true a picture of the actual planktonic conditions as the series of vertical nets sampling the whole column of water and fished from the stationary ship in as strictly standard fashion as possible. The N 70 H nets, each being towed for $\frac{1}{4}$ mile (approximately 463 m.), collected much greater quantities of material than did the N 70 V nets fishing the upper 100 m., for these were hauled vertically for only 50 m. (50–0 and 100–50 m.), and this was the intended function of the N 70 H nets, to collect larger quantities of any species should more material be required for investigation, and to give a greater chance of recording the rarer forms. It is in this latter way that they have been particularly useful, and frequent reference is made to the N 70 H nets in respect to the rarer forms. They have also provided important evidence regarding the vertical migration of the commoner species.

Whilst the numbers of this and that species might vary very greatly at points quite short distances apart the total number of Copepods at different points throughout the area remained remarkably constant. Fig. 53 shows the average number present per 50 m. haul with the N 70 V net in the top 250 m. at all stations in the area. Out of a total of 76 stations only 1 had less than 1000 per 50 m. haul (485), 44 stations had from 1000 to 5000, 24 from 5000 to 10,000, 5 from 10,000 to 20,000 and 2 over 30,000 (33,000 and 36,000). But this apparent evenness of distribution is largely due to the large number of the small Copepod *Oithona frigida*. If we eliminate this species we find that out of the 76 stations 32 have less than 1000 Copepoda per 50 m. haul in the top 250 m., 34 have from 1000 to 5000, 7 from 5000 to 10,000 and 3 over 10,000 (16,000, 28,000 and 35,000).

The late Mr Andrew Scott drew attention to the increase in the number of species with the increase in depth down to 750 m. This he showed in the form of a curve which is reproduced in Fig. 54; this interesting figure should be compared with the curves of temperature and salinity typical for this region, which are shown in Fig. 5. It would appear that only a limited number of species have been able to adapt themselves to the conditions of the cold Antarctic surface layer. Those which have succeeded occur in large numbers.

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[1] Mr Scott in a letter of October 1929 wrote regarding this species: "Brady found it in the Challenger plankton off Kerguelen Island very abundantly. One gathering was purely *Drepanopus*. I cannot trace any (Antarctic) record since Brady's time. It is curious it did not turn up in the Terra Nova collection."

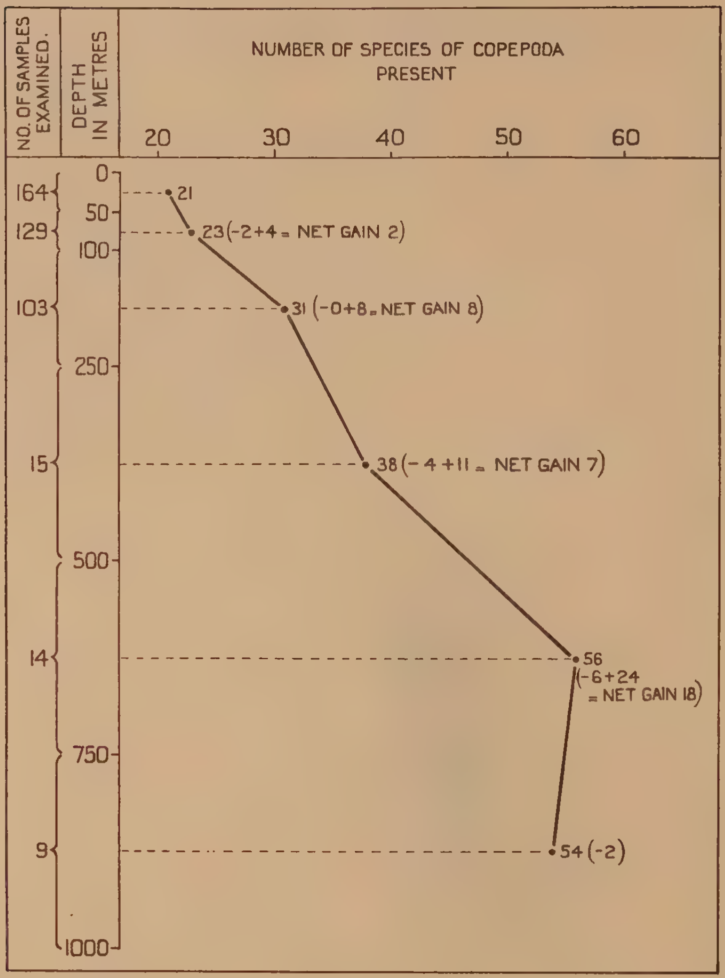

Fig. 54. Curve prepared by the late Mr Andrew Scott showing the increasing number of species of Copepoda with increasing depth in the South Georgia region of the Antarctic Zone.

The mean vertical distributions of the more important species are compared in Figs. 55 and 56; here again reference should be made to the temperature and salinity curves.

CALANIDAE

Calanus simillimus, Giesbr. Whilst this species was found throughout the area, it was not so abundant as *C. propinquus* or *C. acutus*. For the December-January South Georgia survey, 1926–7, the average number per 50 m. haul with the N 70 V net in the top 250 m. of water was only 18, the maximum number per 50 m. haul being 459 (at St. WS 38 50–0 m.). A complete record of its occurrence is given in Appendix II, and its distribution in the top 250 m. is shown in Fig. 57. Farran (1929), in his report on the Terra Nova collection, describes it as "frequent to the south of New Zealand between 50° and 60° S. and at two stations south of 60° S". Previously Wolfenden (1908) from the National Antarctic (Discovery) collection gave a similar distribution, but recorded it at one station in 84° S. It was also taken in the Antarctic, but less frequently, by the 'Gauss' (Wolfenden, 1911).

Whilst it is an Antarctic species it is not strictly limited to the Antarctic Zone. Between South Georgia and the Falkland Islands it occurred in comparatively large numbers between 250 and 50 m. at St. WS 69, which is well across the Convergence line with temperatures of 3·42° C. at 200 m., 4·23° C. at 100 m., and 6·79° C. at 60 m. At St. 70 it was limited to a small number between 500 and 250 m. depth at temperatures of 3·76° C. at 500 m. and 4·07° C. at 300 m. Between Tristan da Cunha and South Georgia it was absent from Sts. 9 and 10, which are farther to the north in latitude 46° S.

It was more or less evenly distributed immediately around South Georgia in water of both Bellingshausen Sea and Weddell Sea origin; Fig. 57 should be compared with Fig. 6, particularly in regard to the "A" line to the north. In March 1926 it showed a somewhat patchy distribution, as will be seen on reference to the Table in Appendix II, Sts. 13–21 and 30–31. On account of this, the small numbers recorded and the limited observations, it is impossible on the present data to gauge its seasonal distribution.

Its mean vertical distribution compared with other species at deep-water stations is shown in Fig. 55. Its vertical distribution at individual stations round South Georgia and on the oceanic lines is shown in Figs. 58 and 59. The species was shown to exhibit a marked diurnal vertical migration. This is discussed and illustrated in comparison with other forms on pp. 233–235.

Calanus minor, Claus. Only a single specimen, female, was taken in the warm intermediate layer at a depth of 750–500 m. Temperature 1·82–1·94° C.; salinity 34·6–34·69 °/₀₀. Not previously recorded in the Antarctic Zone.

Calanus propinquus, Brady. The complete record of the occurrence of this species is shown in Appendix II. It had a general but by no means even distribution throughout the area. It was abundant in the open ocean. The average number per 50 m. haul with the N 70 V net in the top 250 m. of water at the oceanic Sts. 9–12 (approaching South Georgia from Tristan da Cunha) and Sts. 160, 161, WS 67–70 (between South Georgia and the Falkland Islands) was 1082; whereas a similar average for stations round South Georgia in the December–January survey, 1926–7, was only 50. It must be remembered that the two oceanic lines were taken in February (1926 and 1927), and a seasonal difference may to some extent account for the difference, but not altogether (see below). This distribution is shown in Fig. 60. It is seen that round South Georgia it was most abundant over the deeper water. Its range was unrestricted by the line of Antarctic Convergence. On the line to the Falkland Islands the greatest number was recorded in the top 50 m. at St. 70 across the line of Antarctic Convergence, Fig. 62; and on the line from Tristan da Cunha the greatest number was recorded in the top 50 m. at St. 11 south of the line of Antarctic Convergence. Round South Georgia it appeared to be more abundant in the water of Weddell Sea origin, arriving from the east and in the mixture of this water and Bellingshausen Sea water to the west, than in the pure Bellingshausen Sea stream on the A line to the north. Fig. 60 should be compared

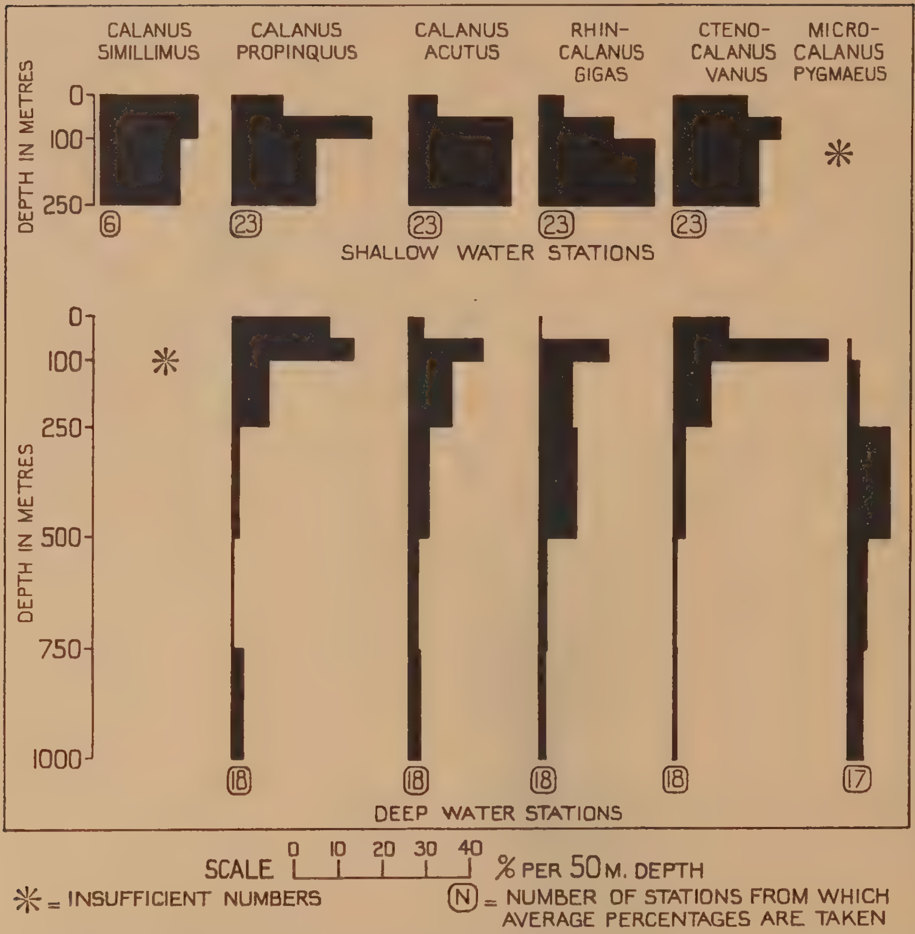

Fig. 55. Diagrams showing the mean depth distribution of the commoner species of Copepoda at shallow- and deep-water stations. Proportions expressed as percentages per 50 m. depth.

with the water-movement chart in Fig. 6. The series of consecutive N 100 H nets described on p. 252 indicated that it occurred in well-defined patches.

The species was first found in the Antarctic by the 'Challenger',[1] and has subsequently been recorded by most Antarctic expeditions: 'Belgica',[2] National Antarctic ('Discovery'),[3] 'Gauss',[4] 'Scotia',[5] 'Terra Nova',[6] 'Aurora'[7] and 'Vikingen'.[8] Farran (1929) in his report on the Terra Nova collection writes as follows:

> One of the most characteristic and plentiful of the Antarctic copepods, though not so abundant as *Calanus acutus*. It occurred on almost every station within the Antarctic circle, adults, mainly females, being common between 66° 30′ and 76° S, but scarce under the ice south of 76° S. North of 66° 30′ very few adults were found though the younger stages were abundant on several stations. The most northern point at which an adult female was taken was 54° 38′ S.

It was "by far the most abundant of all the Copepods" in the Aurora collections, and was very common at the winter quarters of the Gauss Expedition, approximately

[1] Brady (1883).
[2] Giesbrecht (1902).
[3] Wolfenden (1908).
[4] Wolfenden (1911).
[5] Scott (1912).
[6] Farran (1929).
[7] Brady (1918).
[8] Ottestad (1932).

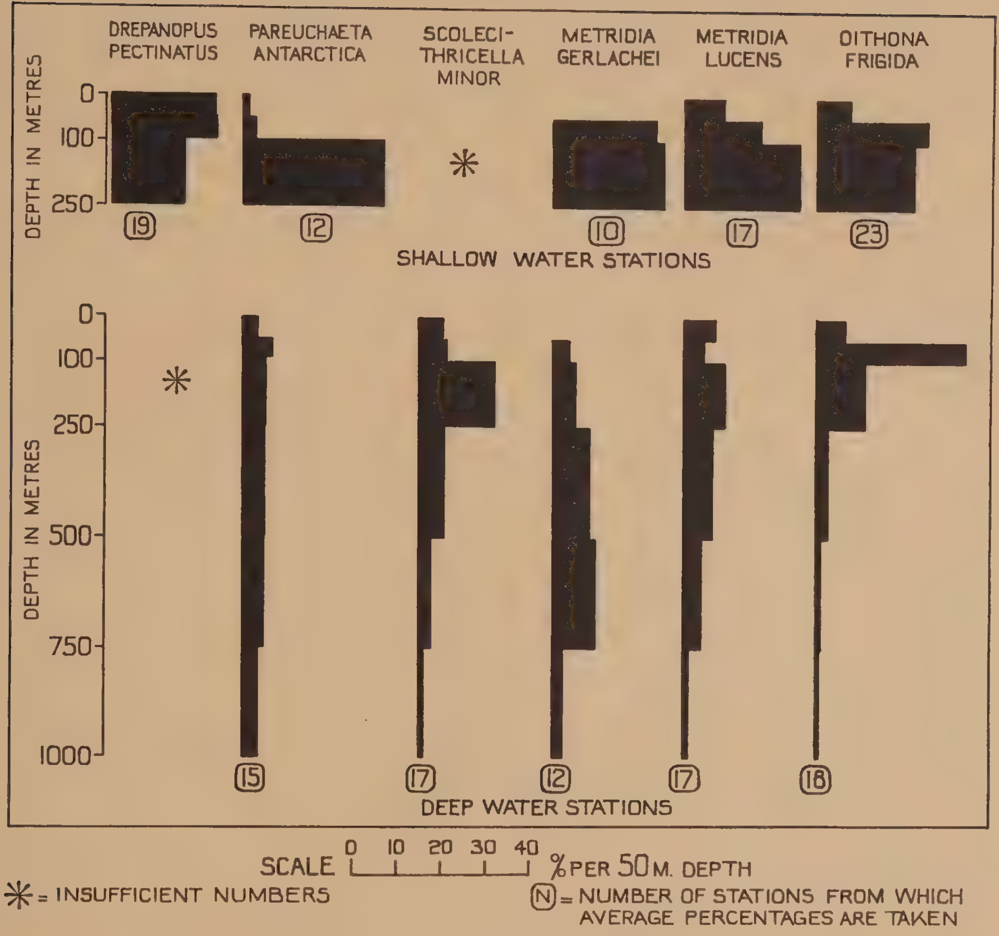

Fig. 56. Continuation of Fig. 55.

66° S. In our area we see it taken in very large numbers as far north as 46° S., far across the line of the Antarctic Convergence.

Its seasonal distribution may be gauged, only on the slender material available, by comparing the C line of five stations taken in November 1926, December 1926, March 1926 and again in May 1927, when the average numbers per 50 m. haul with the N 70 V net in the top 250 m. for each season are 5, 105, 143 and 69 respectively. We see a rapid increase in summer from a small spring population, and a falling off in the autumn.

Its vertical distribution round South Georgia is shown in Fig. 61, and that approaching South Georgia from the north-east in February 1926, and between South Georgia and the Falkland Islands in Fig. 62. It was usually most abundant in the top 100 m., but St. WS 67, between South Georgia and the Falkland Islands, shows a marked exception when large numbers were taken between 1000 and 750 m., and very few in the water above this depth. Its mean vertical distribution at deep-water stations is shown in Fig. 55. The species showed indications of diurnal vertical migration; this is further discussed on p. 234 and illustrated in Figs. 103 and 106.

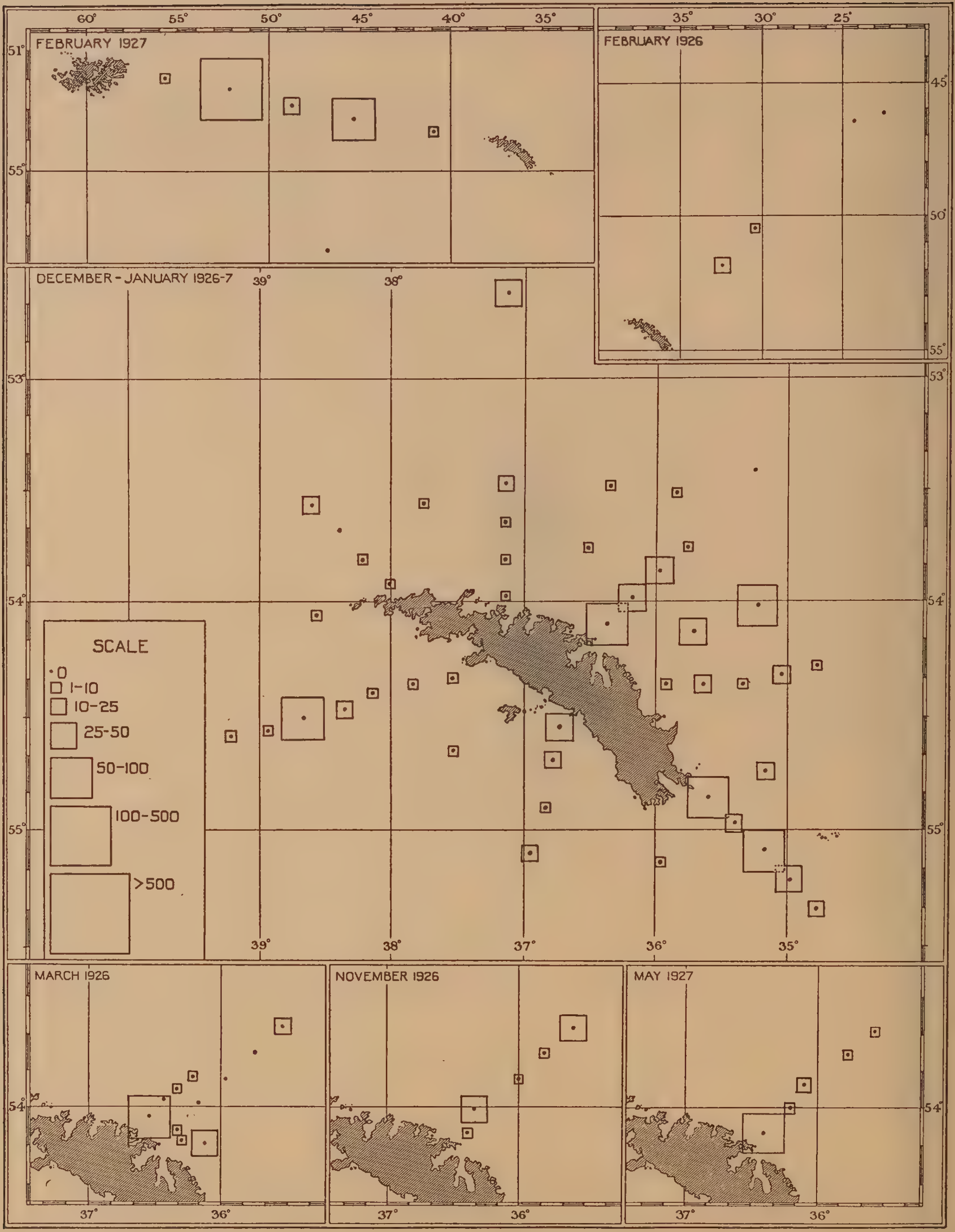
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
0
1-10
10-25
25-50
50-100
100-500
>500
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 57. Charts showing the distribution of *Calanus simillimus* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

Calanus acutus, Giesbr. This species was the most abundant of all the larger Copepoda in our collections. The complete record of its occurrence is given in Appendix II. For the December-January South Georgia survey, 1926–7, the average number per 50 m. haul with the N 70 V net in the top 250 m. of water was 152, whilst the maximum number per 50 m. haul was 2075.

Farran (1929) in his report on the Terra Nova Copepoda writes:

> This is the most characteristic antarctic copepod in the collection, being more plentiful than either *Calanus propinquus* or *Metridia Gerlachei*. The few specimens from north of 60° S appeared to have been dead when taken and the most northerly point from which it can definitely be recorded as living is in 61° 22′ S.

It was taken also by the Belgica,[1] National Antarctic (Discovery),[2] Scotia[3] and Gauss[4] Expeditions, in the Antarctic. Ottestad (1932) writes:

> The expedition with S.S. 'Vikingen' 1929–30 to the Weddell Sea found *Calanus acutus* at all stations. The northernmost location is situated at 54° 27′ S and there is no sign of the species found having been dead. From the existing data it may be concluded that *Calanus acutus* is a typical Antarctic species, and that the most northern limit of its distribution lies between 50° and 60° S.

Whilst a few specimens were taken at St. 9 as far north as latitude 46° S, two at 50–0 m. in water temperature of 6·8–7·2° C. and three at 250–100 m. in water temperature of 3·5–4·7° C., and a few at St. WS 70 against the Falkland Islands, the true Antarctic nature of the species is clearly shown in Fig. 65. Here the vertical distribution of the species on the oceanic lines between South Georgia and the Falkland Islands and South Georgia and Tristan da Cunha is shown, and the marked contrast on either side of the Antarctic Convergence, which lies between Sts. WS 67 and WS 68 on the former line, and Sts. 10 and 11 on the latter line, is most striking. On the Falkland Islands line it is seen at the lower depths of Sts. WS 68 and 69, being carried below the sub-Antarctic water. Fig. 65 should be compared with the temperature and salinity curves shown in Figs. 9 and 10. This almost complete limitation to the Antarctic Zone is also seen in Fig. 63, where the general distribution in the area is shown, it being particularly abundant at St. 161 far to the south-west of South Georgia. Immediately round South Georgia it was distributed equally in water of both Bellingshausen Sea and Weddell Sea origin, but was more abundant to the west, south and east than to the north.

Its seasonal distribution may be gauged, admittedly on slender material, by comparing the C lines taken in November 1926, December 1926, March 1926, and May 1927, when the average numbers per 50 m. haul with the N 70 V net for the top 250 m. from the five stations in each season were 64, 112, 232, and 5 respectively, showing an increase towards late summer and a falling off on the approach of winter.

Its mean vertical distribution at both shallow and deep-water stations is shown in Fig. 55. It was rarely abundant in the top 50 m., but was taken in the larger numbers between 50 and 250 m.; it occurred in small numbers in hauls between 2000 and 1000 m. The depth distribution round South Georgia is shown in Fig. 64. No vertical diurnal migration was apparent from our results; this is further discussed on p. 236.

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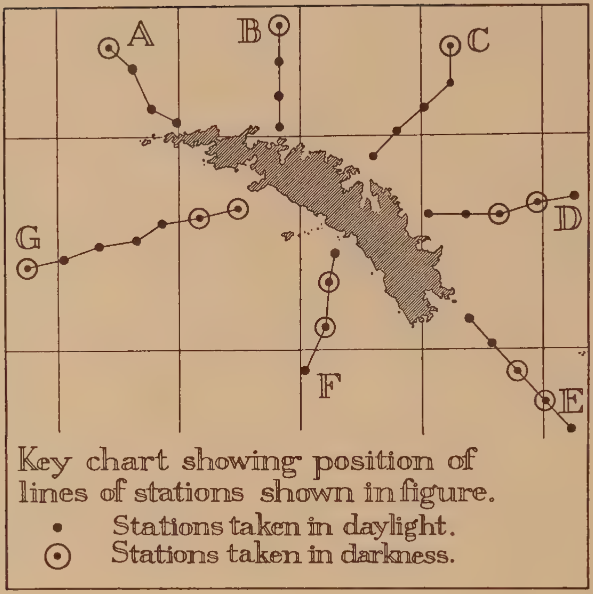
[1] Giesbrecht (1902).
[2] Wolfenden (1908).
[3] Scott (1912).
[4] Wolfenden (1911).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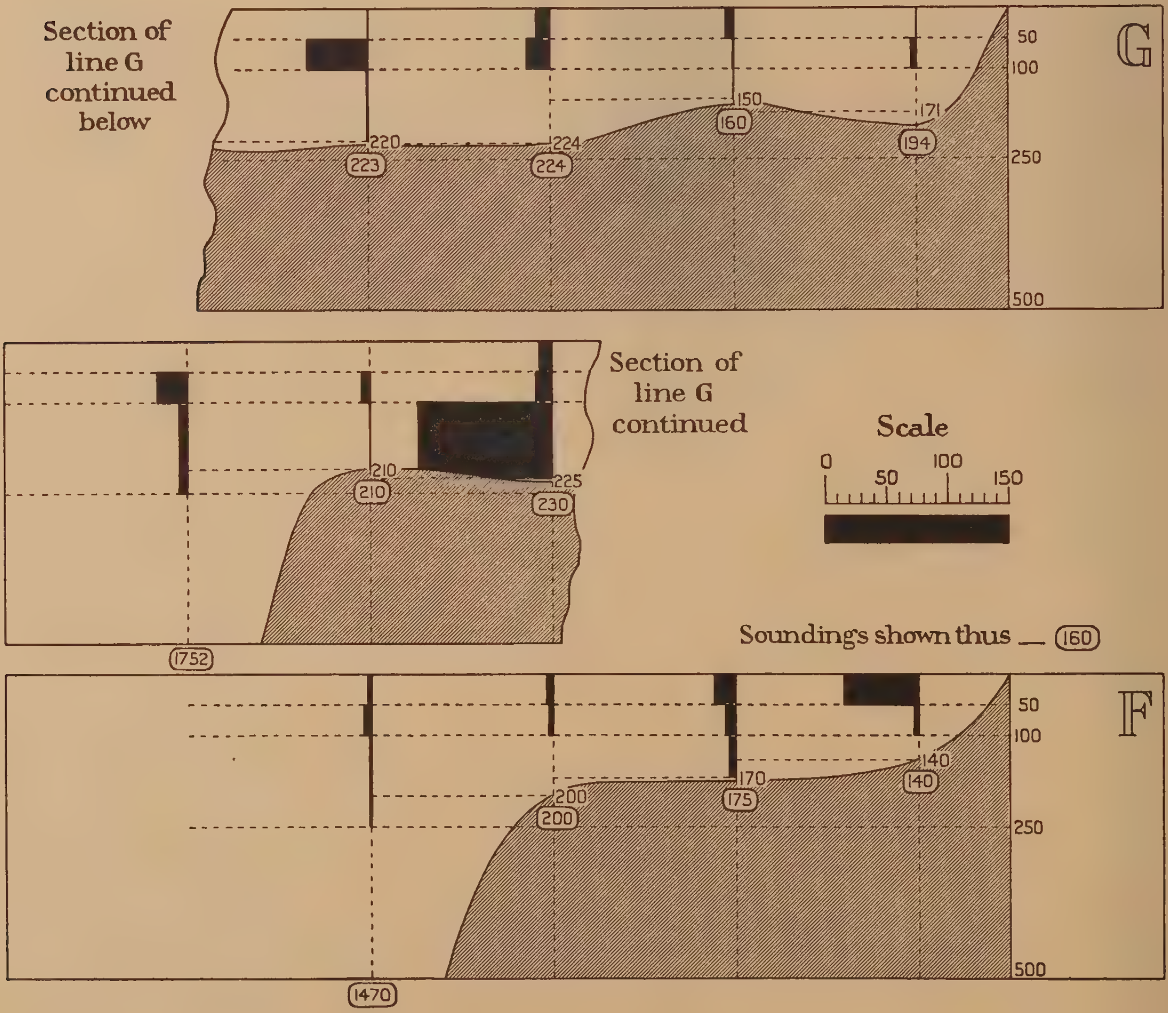
Key chart showing position of lines of stations shown in figure.
• Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 58. Showing the vertical distribution of **Calanus simillimus**, Giesbr. down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



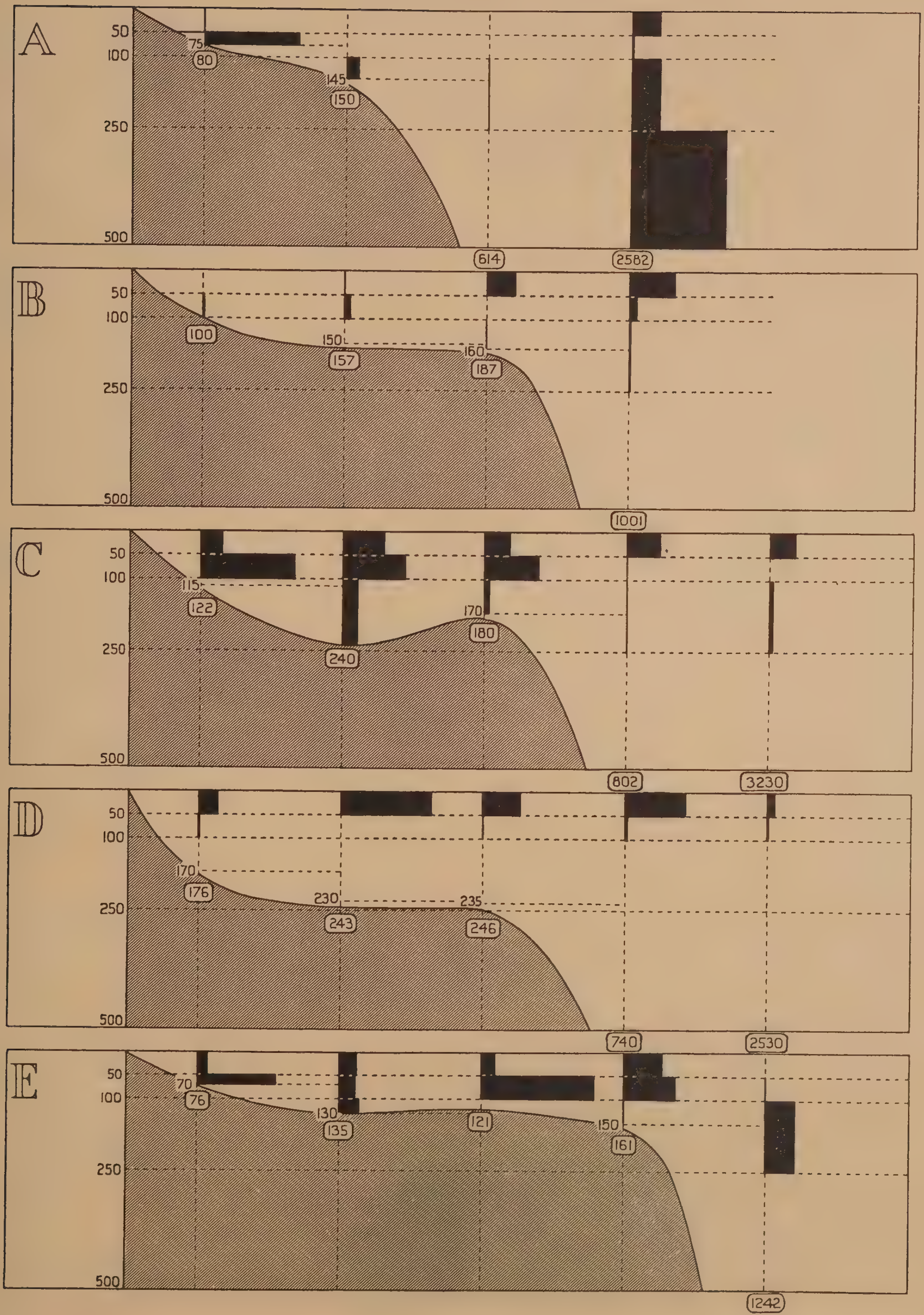
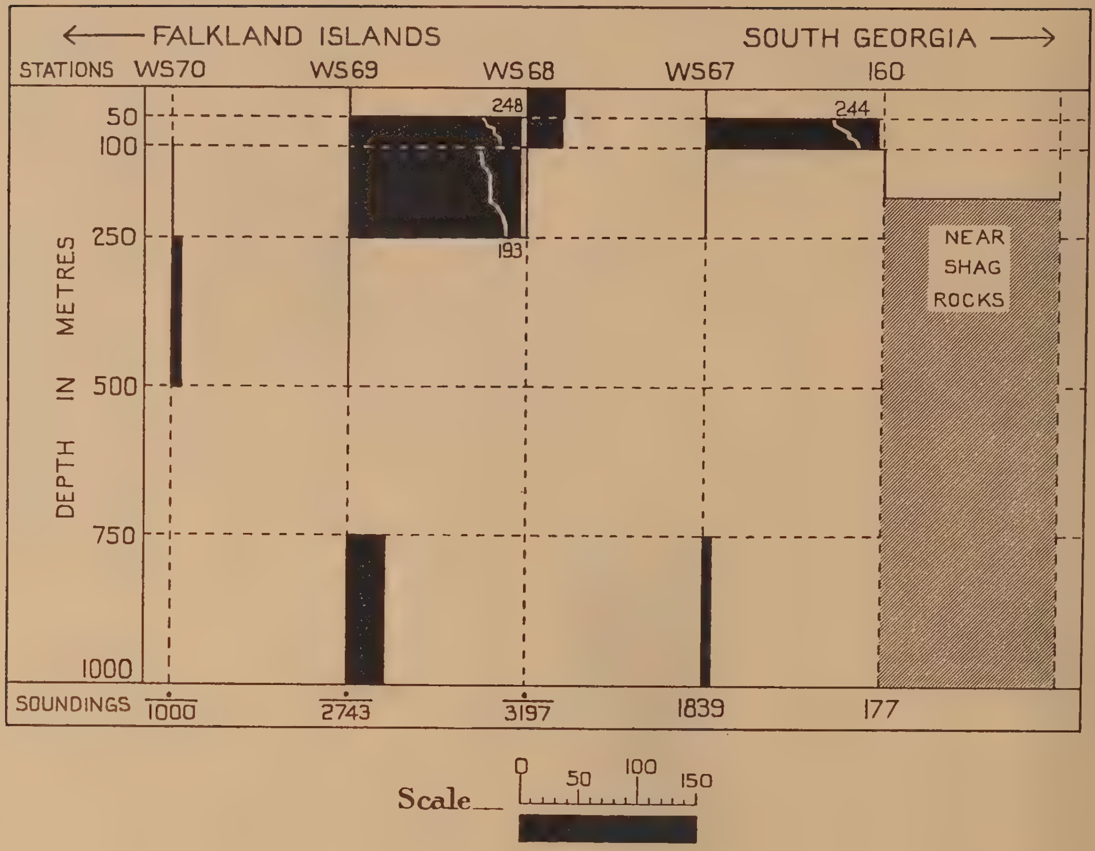


Fig. 58—*continued*



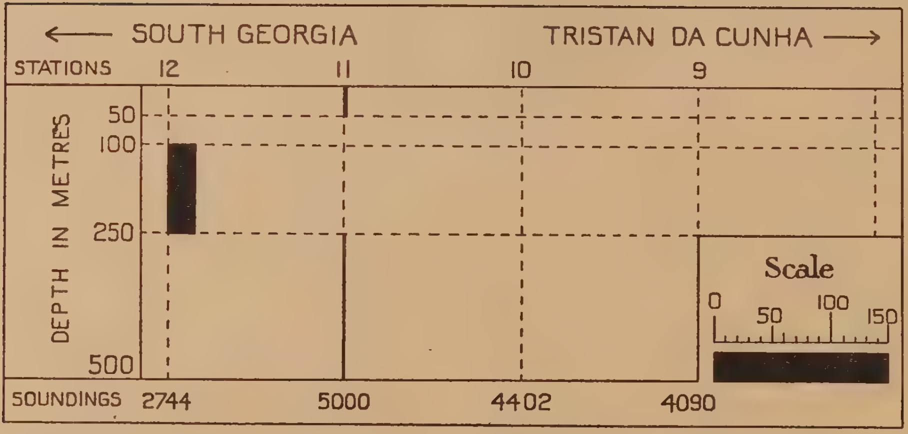
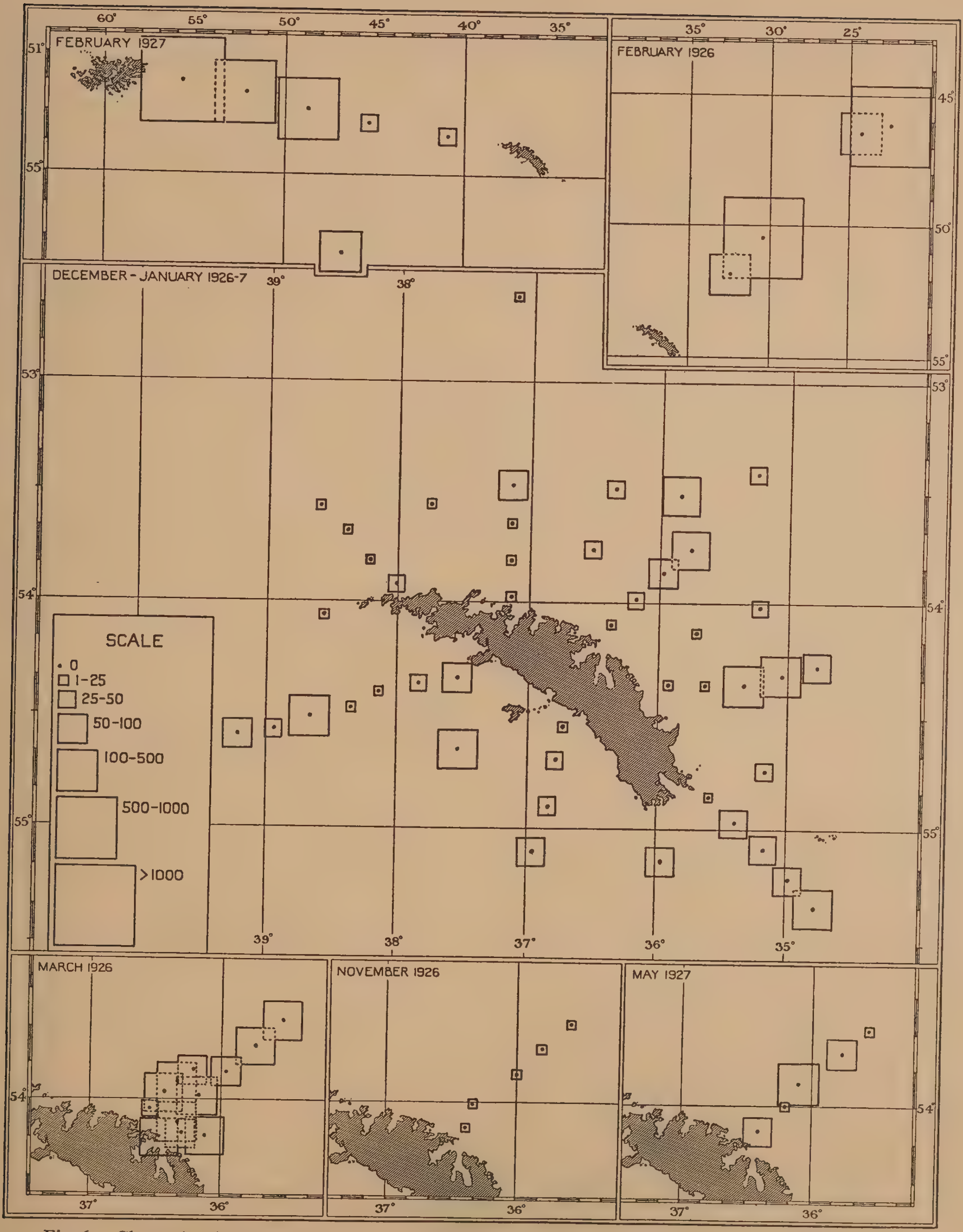


Fig. 59. Showing the vertical distribution of *Calanus simillimus* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.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FEBRUARY 1926
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SCALE
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>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
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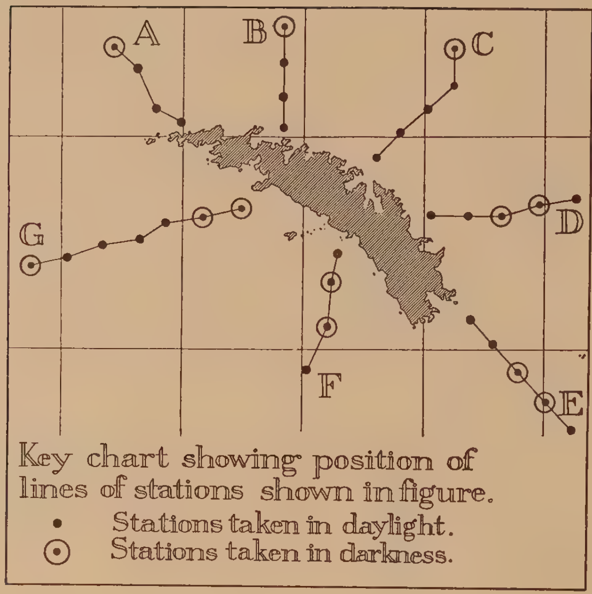
Fig. 60. Charts showing the distribution of *Calanus propinquus* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.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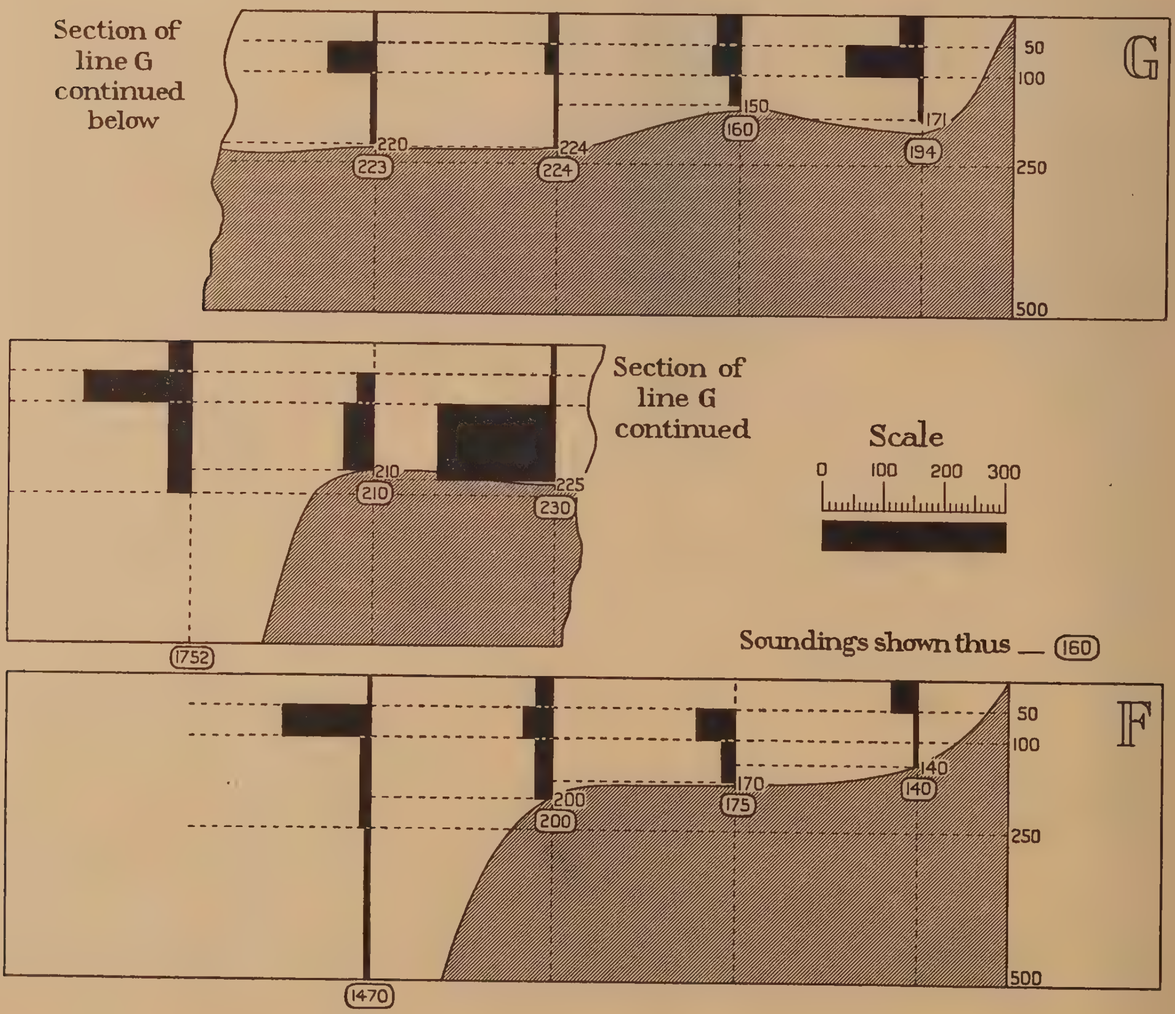
Key chart showing position of lines of stations shown in figure.
• Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 61. Showing the vertical distribution of **Calanus propinquus**, Brady down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



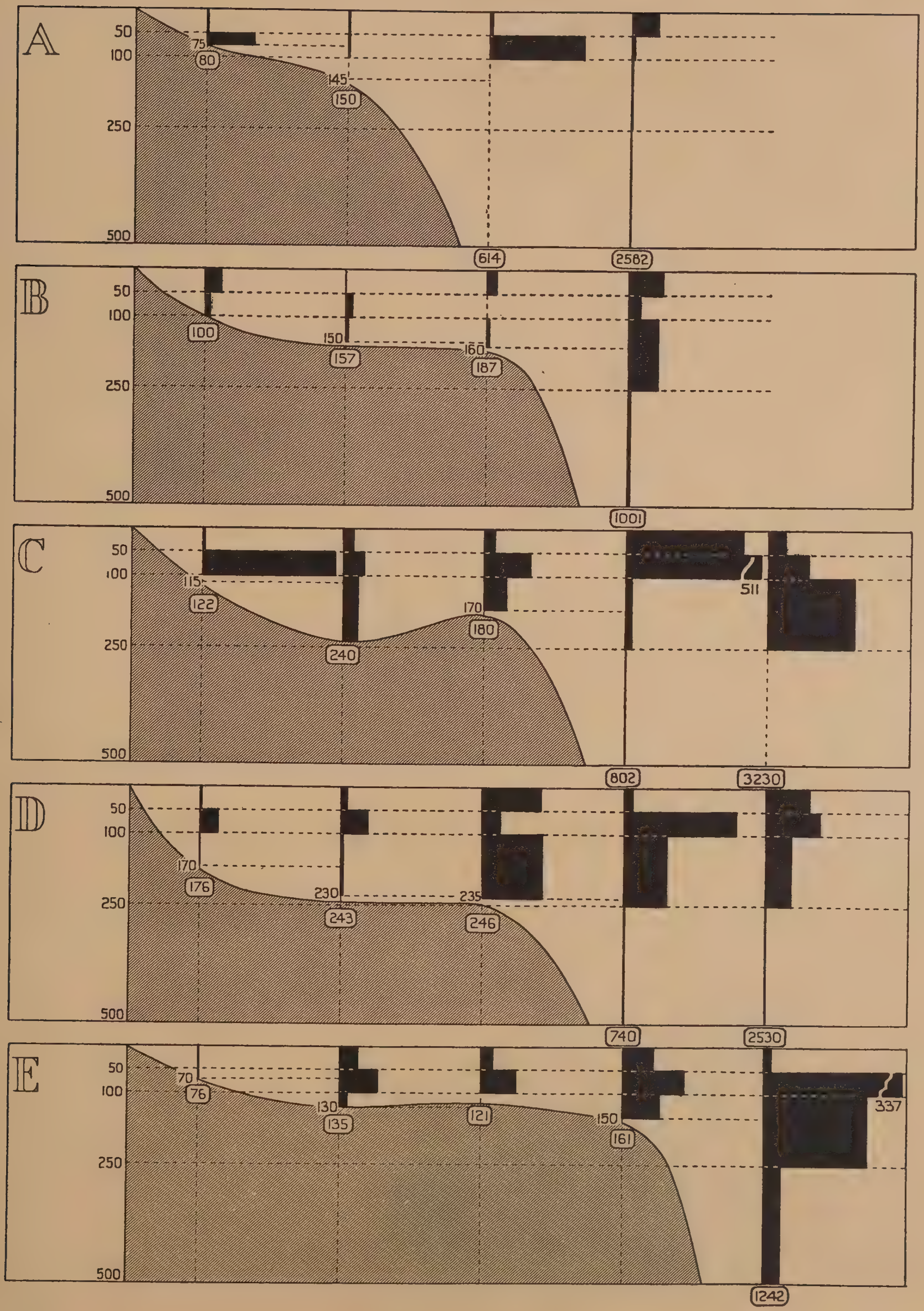


Fig. 61—*continued*

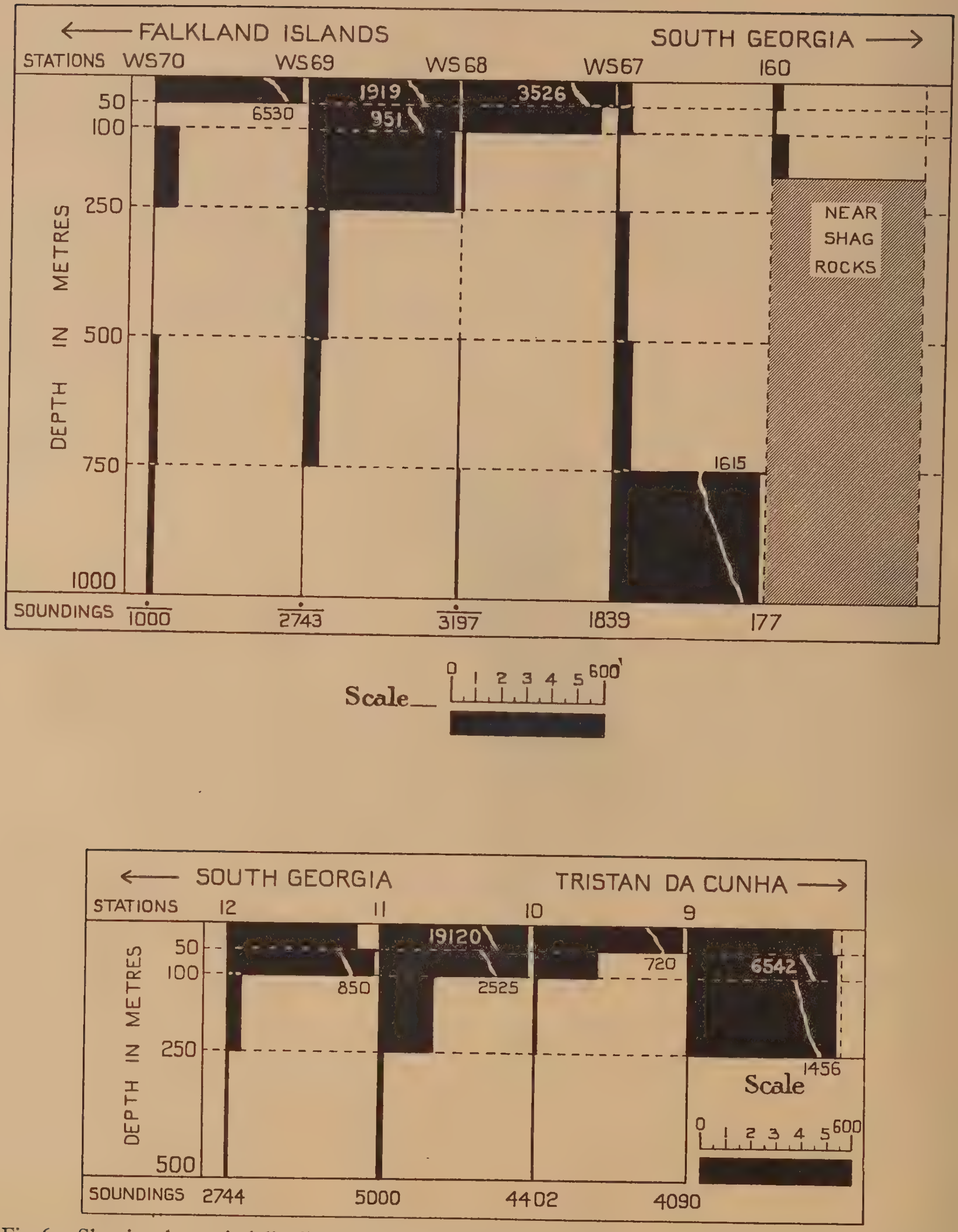
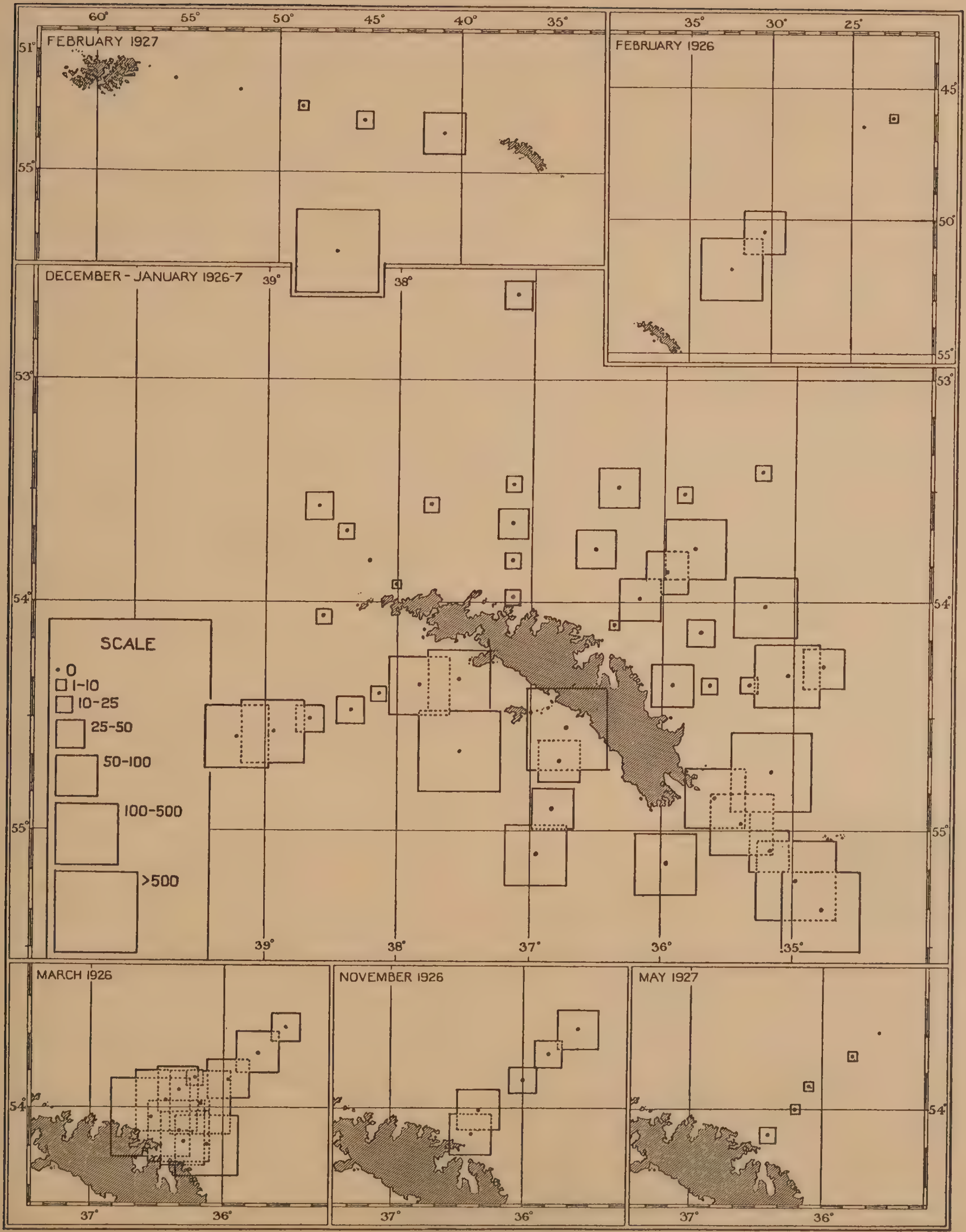


Fig. 62. Showing the vertical distribution of *Calanus propinquus* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.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37°
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SCALE
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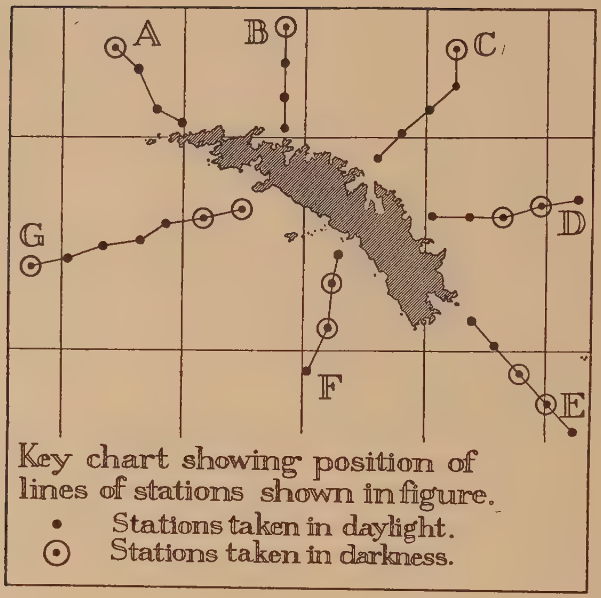
50-100
100-500
>500
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 63. Charts showing the distribution of *Calanus acutus* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.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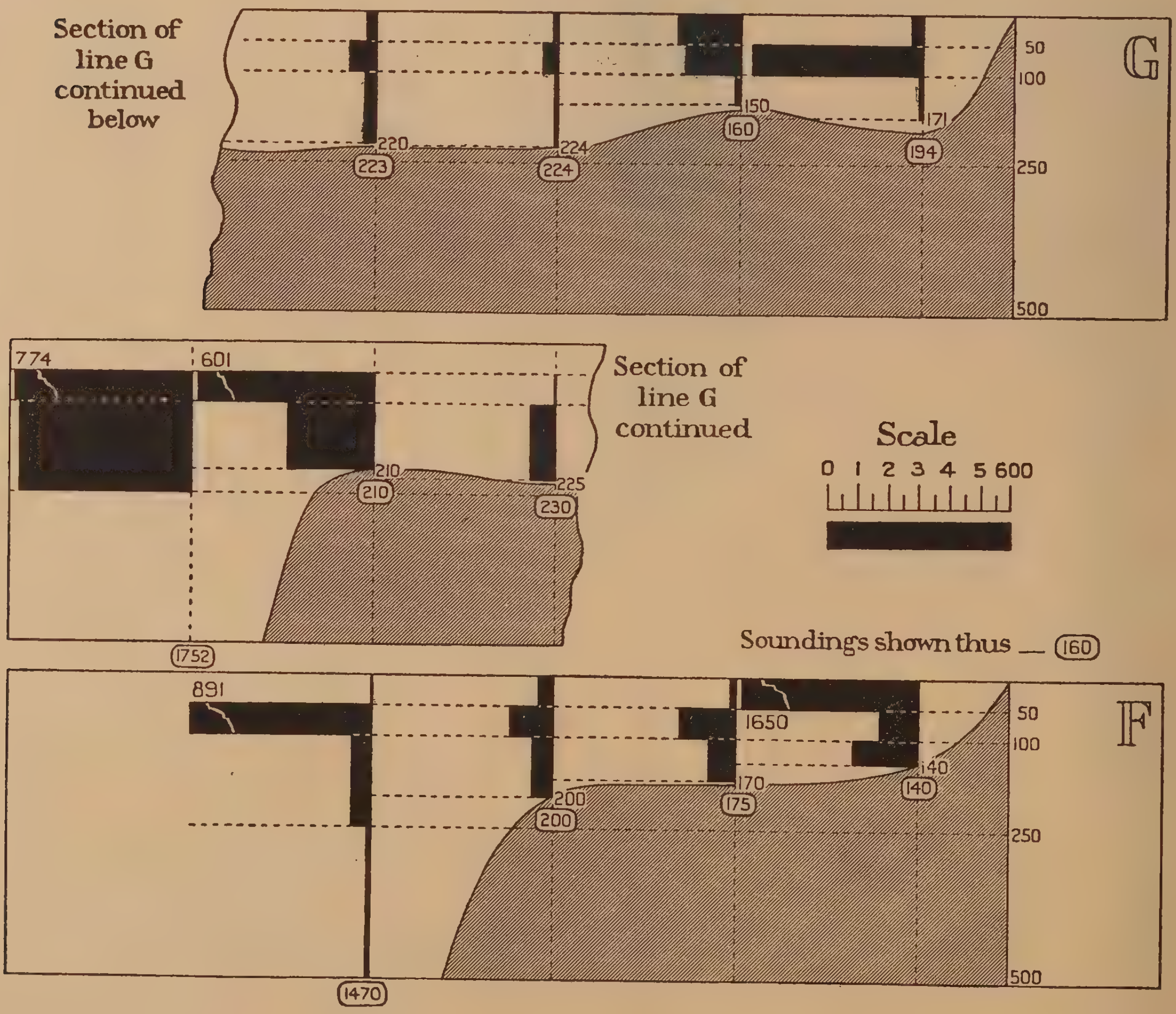
Key chart showing position of lines of stations shown in figure.
● Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 64. Showing the vertical distribution of **Calanus acutus**, Giesbr. down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



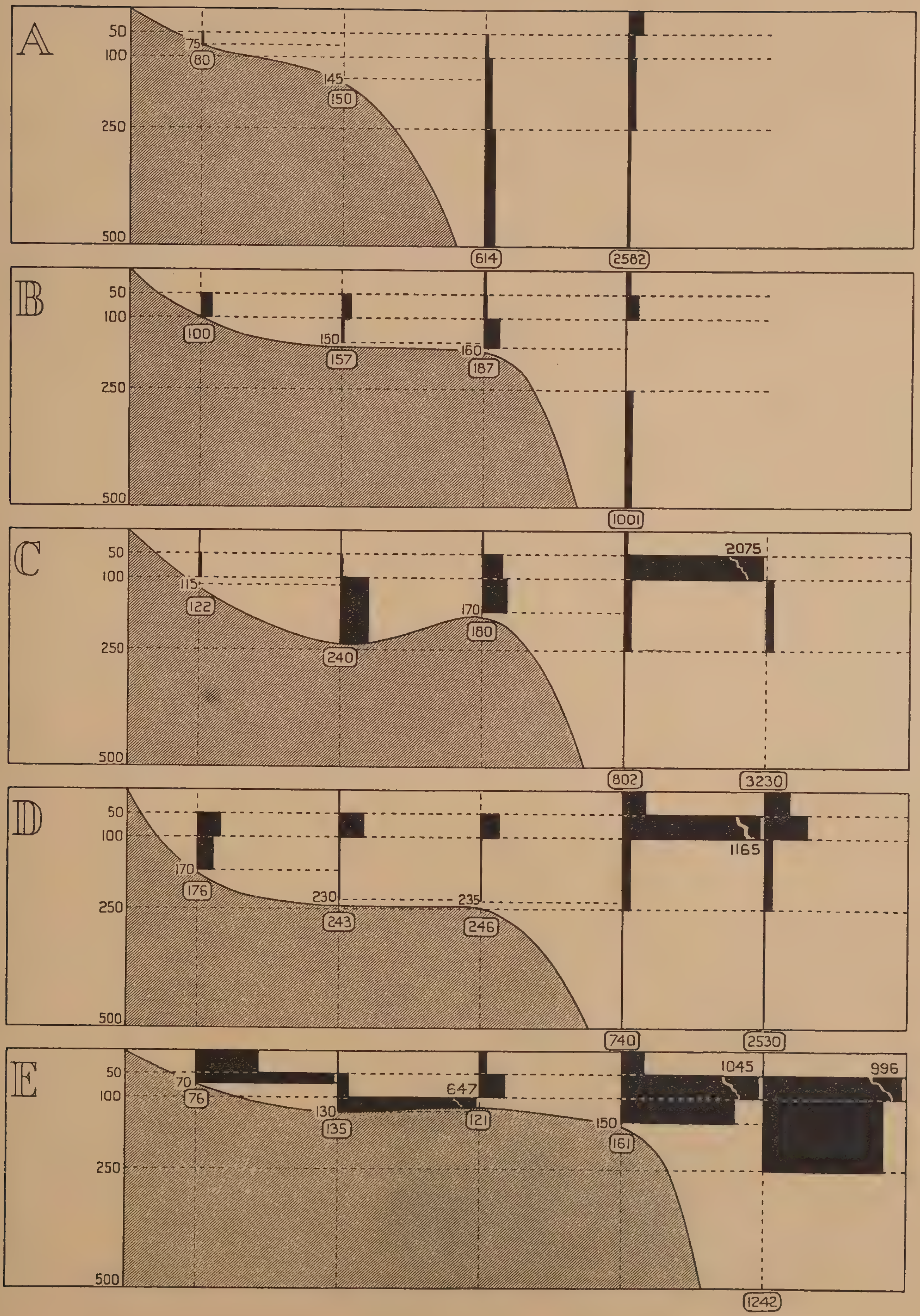


Fig. 64—*continued*

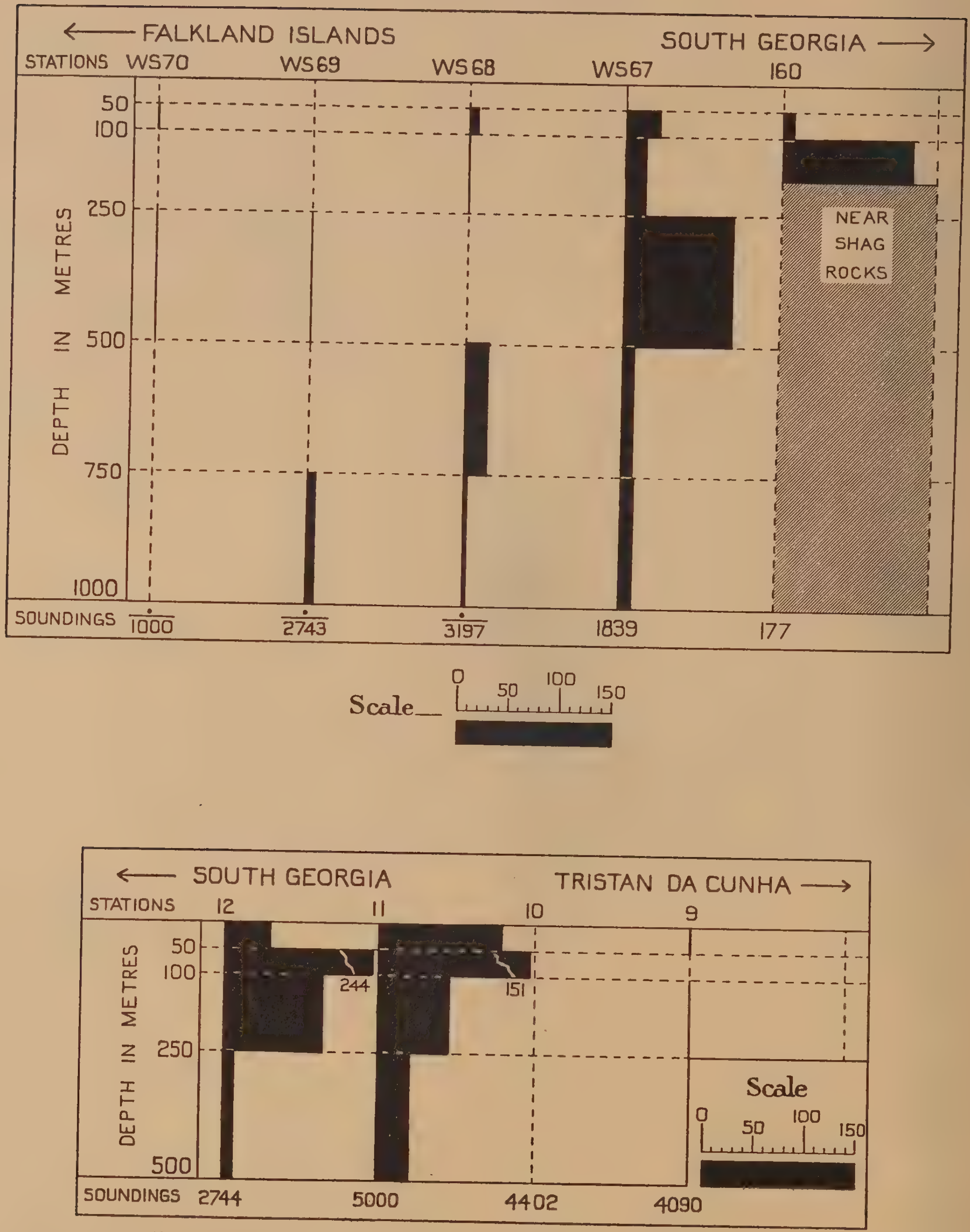


Fig. 65. Showing the vertical distribution of *Calanus acutus* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.

Eucalanus elongatus (Dana). Four female specimens taken at four different stations—three in the Antarctic Zone—and all in the warm intermediate layer, except one at St. 137 in water which is a mixture of this layer and the colder Antarctic surface layer above. Temperature 1·94° C.; salinity 34·47–34·60 $^{\circ}/_{\circ\circ}$.

St. 137	1 ♀ at	500–250 m.	St. WS 67 ...	1 ♀ at	1000–750 m.
St. WS 38 ...	1 ♀ at	1000–750 m.	St. WS 70 ...	1 ♀ at	750–500 m.

It was taken by the 'Terra Nova'[1] as far south as 60°.

Eucalanus acus, Farran. This species was widely distributed throughout the region but rarely abundant. It occurred both in the cold Antarctic surface layer and in the warmer intermediate layer. It was first described by Farran (1929) in his report on the collections of the Terra Nova Expedition. He found it "taken in considerable numbers from the surface to 80 m. in a limited area south of New Zealand from 51° 22′ S to 61° 18′ S."

St. 124	N 70 H	24 ♀	at	65 m.	St. 137	N 70 V	1	at	100–50 m.
		4	at	130 m.		N 70 H	6	at	120 m.
	N 100 H	18	at	90 m.		N 100 H	12 ♀	at	66 m.
		3 ♀	at	180–90 m.			1 ♀	at	132 m.
St. 125	N 70 V	2	at	250–100 m.	St. 138	N 70 V	2	at	100–50 m.
		3	at	500–250 m.		N 100 H	3 ♀	at	77 m.
	N 70 H	1	at	70 m.			1 ♀	at	155 m.
		2	at	140 m.	St. 139	N 100 H	1 ♀	at	90 m.
	N 100 H	4 ♀	at	0–5 m.	St. 161	N 70 V	1	at	1000–750 m.
St. 126	N 70 V	1	at	100–50 m.	St. WS 18 ...	N 70 V	1	at	50–0 m.
	N 100 H	5 ♀	at	47 m.		N 70 H	9	at	46 m.
St. 127	N 70 H	7	at	79 m.			4	at	128 m.
	N 100 H	1 ♀	at	82 m.	St. WS 19 ...	N 70 H	3	at	0–5 mm.
St. 128	N 70 V	1	at	160–100 m.			1	at	62 m.
St. 129	N 70 V	1	at	100–50 m.			2	at	155 m.
		3 ♀	at	750–500 m.		N 100 H	1 ♀	at	0–5 m.
St. 131	N 70 V	1	at	100–50 m.	St. WS 20 ...	N 70 H	8	at	71 m.
	N 70 H	2	at	62 m.			2	at	164 m.
		8	at	124 m.		N 100 H	3 ♀	at	86 m.
	N 100 H	5 ♀	at	128 m.			2 ♀	at	190 m.
St. 132	N 70 V	1	at	170–0 m.	St. WS 21 ...	N 70 V	1 ♀	at	250–100 m.
	N 70 H	1	at	90 m.		N 70 H	8	at	90 m.
St. 133	N 70 V	2 ♀	at	100–50 m.			1	at	192 m.
		1	at	270–100 m.		N 100 H	1 ♀	at	95 m.
	N 70 H	2	at	0–5 m.			4 ♀	at	192 m.
	N 100 H	1 ♀	at	100 m.	St. WS 22 ...	N 70 V	1	at	100–50 m.
St. 134	N 70 H	2	at	120 m.			2	at	250–100 m.
	N 100 H	2 ♀	at	61 m.			116	at	1000–0 m.
		5 ♀	at	123 m.			1	at	1000–750 m.
St. 136	N 70 H	12	at	96 m.		N 70 H	4	at	71 m.
	N 100 H	7 ♀	at	99–0 m.			1	at	165 m.

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[1] Farran (1929).

St. WS 22	N 100 H	5 ♀	at	82 m.
St. WS 24	N 70 H	4	at	117 m.
St. WS 26	N 70 V	3	at	100–50 m.
		2	at	250–100 m.
	N 70 H	6	at	140 m.
St. WS 28	N 70 H	1	at	68 m.
St. WS 30	N 70 H	7 ♀	at	100 m.
	N 100 H	4 ♀	at	134 m.
St. WS 31	N 100 H	6 ♀	at	53 m.
St. WS 33	N 70 V	1	at	130–100 m.
	N 100 H	1 ♀	at	65 m.
St. WS 34	N 70 H	1	at	80 m.
	N 100 H	2 ♀	at	100–5 m.
St. WS 35	N 70 V	1	at	150–100 m.
	N 70 H	14	at	131 m.
	N 100 H	1 ♀	at	51 m.
St. WS 36	N 100 H	8 ♀	at	77 m.
St. WS 38	N 70 V	3	at	250–100 m.
		1	at	750–500 m.
	N 100 H	2 ♀	at	106 m.
St. WS 39	N 70 V	1	at	232–100 m.
	N 70 H	4	at	117 m.
	N 100 H	1 ♀	at	173 m.
St. WS 40	N 70 V	1	at	100–50 m.
	N 70 H	2	at	108 m.
	N 100 H	6 ♀	at	72 m.
St. WS 40	N 100 H	5 ♀	at	144 m.
St. WS 41	N 100 H	1 ♀	at	73 m.
		1 ♀	at	146 m.
St. WS 44	N 70 V	1	at	1000–750 m.
St. WS 45	N 70 V	1	at	100–50 m.
		2	at	170–100 m.
St. WS 46	N 70 H	1	at	87 m.
St. WS 48	N 100 H	2 ♀	at	96 m.
St. WS 49	N 100 H	1 ♀	at	69 m.
St. WS 63	N 70 V	1	at	1000–750 m.
St. WS 67	N 70 V	1 ♀	at	1000–750 m.
St. WS 68	N 70 V	8	at	50–0 m.
		10	at	100–50 m.
		1 ♀	at	250–100 m.
		4 juv.	at	500–250 m.
		176 juv.	at	750–500 m.
		57	at	1000–750 m.
St. WS 69	N 70 V	1 ♀	at	250–100 m.
		1 ♀	at	500–250 m.
		17 ♀	at	750–500 m.
		62	at	1000–750 m.
St. WS 70	N 70 V	1376	at	50–0 m.
		1 ♀	at	250–100 m.
		2 juv.	at	500–250 m.
		66 ♀	at	750–500 m.
		388	at	1000–750 m.

Eucalanus sp.

St. 124	4 ♂	at	65 m.
	1 ♂	at	130 m.
St. 134	1 ♂	at	120 m.
St. WS 18	2	at	128 m.
St. WS 21	1	at	90 m.
St. WS 30	1 ♂	at	100 m.

Rhincalanus gigas, Brady. This large Copepod was widely distributed throughout the area. A complete record of its occurrence is shown in Appendix II.

Whilst it is a typically Antarctic Copepod it was taken in small numbers extending across the Antarctic Convergence. Farran (1929) in his report on the Terra Nova collections describes it "from 54° 02′ S southwards to the ice...most numerous between 60° and 70° S". He writes further that "there is a gap of 1200 sea miles between the most northerly record of this species and the most southerly record of *R. nasutus*". In our area the distribution of the two species just overlap, a small number of *R. nasutus* being taken at South Georgia.

Larger catches were made with the larger nets N 100 H than with the N 70 V net, but the results from the N 70 V net are also used in this section, so that its occurrence may be compared with that of other Copepods dealt with in the report (see Fig. 66). In the December–January South Georgia survey, 1926–7, the average number per 50 m. haul with the N 70 V net in the top 250 m. of water was 22. The maximum number per 50 m. haul with the N 70 V net was 640 (St. 15, March 1926).

We have said that this large Copepod *R. gigas* was taken in large numbers by the N 100 H nets, which being of a wider mesh than the N 70 V nets let through nearly all the other Copepoda (except notably *Pareuchaeta antarctica* and *Calanus propinquus*). Because they formed quite a prominent feature of these N 100 H samples, along with the Euphausiacea, Amphipoda and other members of the macroplankton, we have plotted the results of the N 100 H analyses in Fig. 67 in the same manner as the other N 100 H results, i.e. on the basis of the numbers caught in three nets each towed for 1 mile (the nets being fished at approximately 0–5, 50 and 100 m., for exact depths see table in Appendix II). This figure enables the numbers of *Rhincalanus* to be compared at a glance with the numbers of the other members of the macroplankton. On the other hand, it also forms a connecting link in the matter of numbers with the smaller members of the zooplankton as sampled vertically by the N 70 V nets, for this species *R. gigas* is sampled by both nets. We see how much more numerous many of the smaller Copepoda are than the species of the macroplankton. The numbers of *Rhincalanus* seem large when taken by the N 100 H nets, but when sampled by the N 70 V nets and plotted in the same manner as other smaller N 70 V specimens we see that they are present in relatively small numbers. At first sight, when we compare Figs. 66 and 67, the results appear quite contradictory, yet actually this is not so. To begin with, Fig. 67 is showing the sampling of three horizontal layers lying in the top 100 m. or so; Fig. 66 is showing the complete vertical sampling of the top 250 m. The upper N 70 V nets in Fig. 66 are hauled through in 50 m. of water (50–0, and 100–50 m.), and the lower ones through 150 m. (250–100 m.); the number given represents the whole column, being shown as the average number per 50 m. In Fig. 67 the numbers given represent the numbers taken in three miles' tow (i.e. three nets for one mile each), or in 5557·8 m. Now the area of the net opening of the N 100 H net is twice that of the N 70 V net, and further it is of wider mesh, so that the amount of water filtered is considerably greater than that of the N 70 V net. However, neglecting the matter of filtration and considering only the size of net and the length of tow, we see that to compare the numbers shown in the N 100 H net figures with the numbers shown in the N 70 V net figures, we must divide them by approximately 222. Then it must be realized that the N 70 V figures show the average for a vertical column of water which has been sampled all the way up, whereas the N 100 H figures show the numbers taken in three horizontal layers across the upper part of this column and for a mile beyond.

Its seasonal distribution may be gauged, admittedly on slender material, by comparing the C lines taken in November 1926, December 1926, March 1926, and May 1927, when the average numbers per 50 m. haul with the N 70 V net from the five stations on the line were 18, 57, 71 and 20 for the four seasons respectively, showing an increase towards late summer and a falling off on the approach of winter.

The vertical distribution round South Georgia is shown in Fig. 68, and that approaching South Georgia from the north-east in February 1926, and between South Georgia and the Falkland Islands in Fig. 69. It was most abundant between 50 and 250 m. and was not taken at levels below 750 m. Its mean vertical distribution at deep-water stations is shown in Fig. 55. It did not appear to exhibit any vertical diurnal migration.

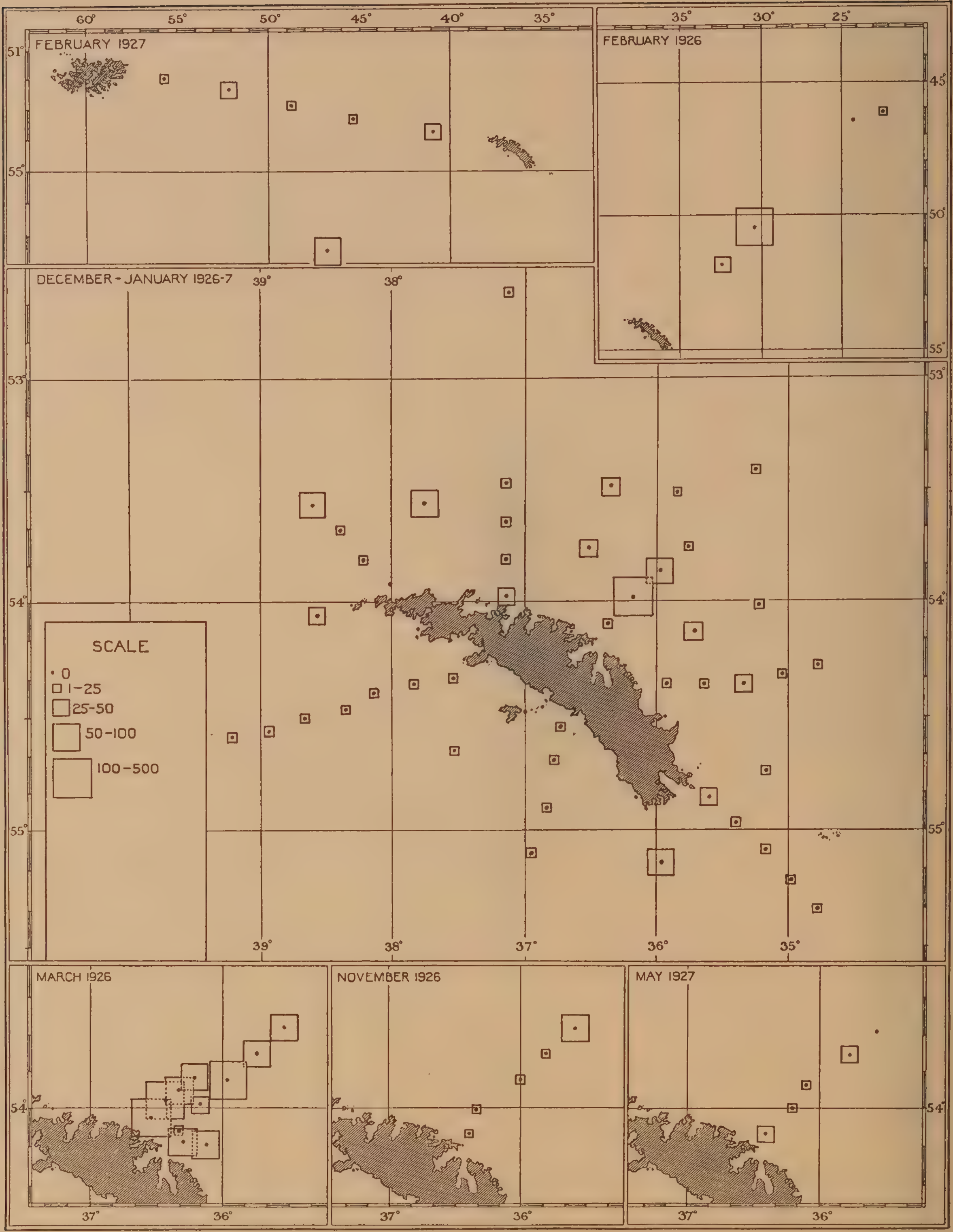
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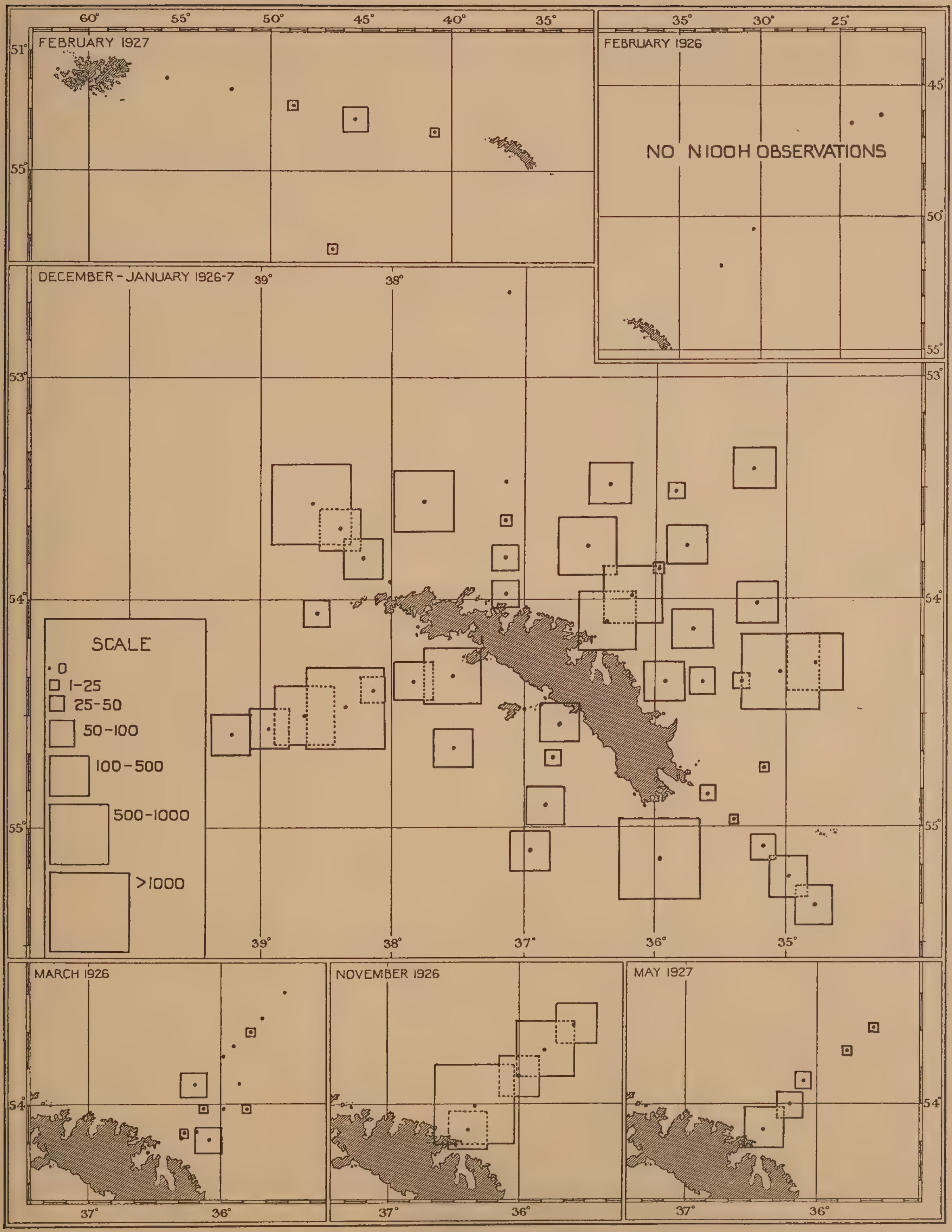
Fig. 66. Charts showing the distribution of *Rhincalanus gigas* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.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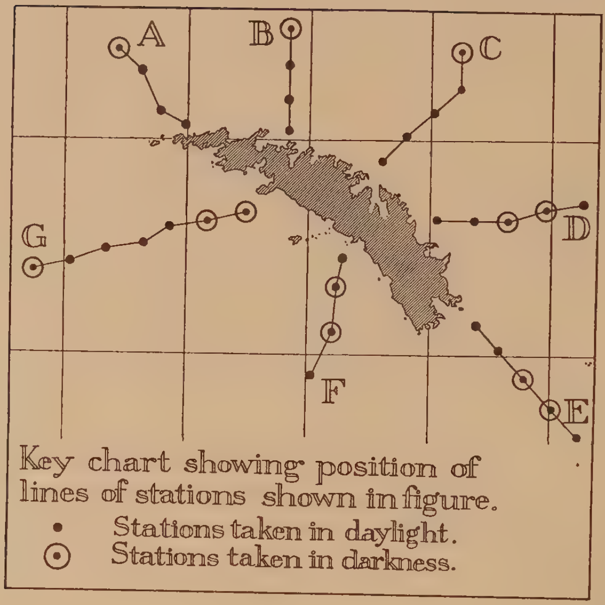
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

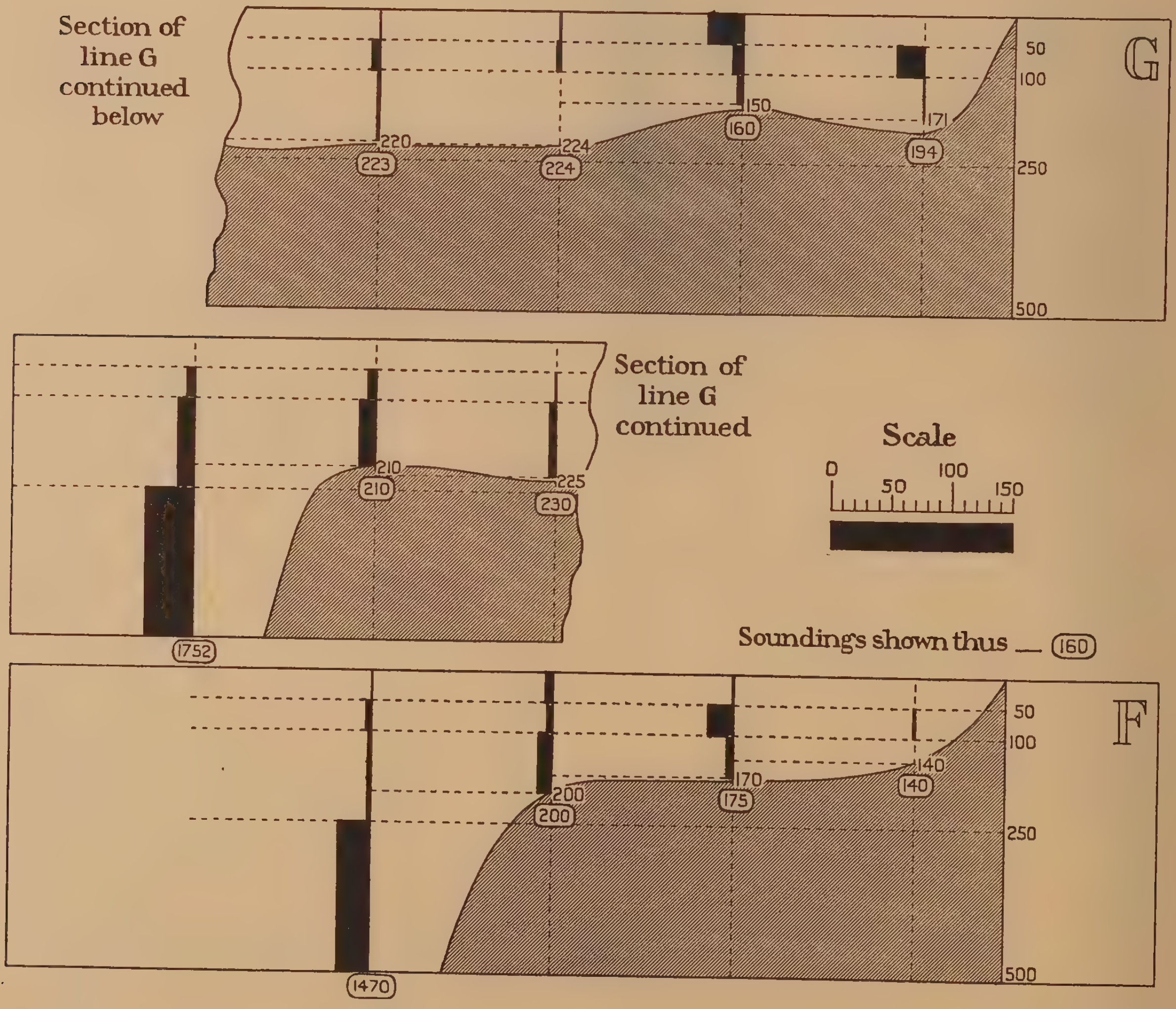
Fig. 67. Charts showing the distribution of *Rhincalanus gigas* at stations in the 1926–7 surveys as shown by the N 100 H nets. The squares represent the numbers taken in three nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively. See discussion in the text regarding the comparison of these charts with those in Fig. 66.



Key chart showing position of lines of stations shown in figure.
- ● Stations taken in daylight.
- ⊙ Stations taken in darkness.

Fig. 68. Showing the vertical distribution of **Rhincalanus gigas**, Brady down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



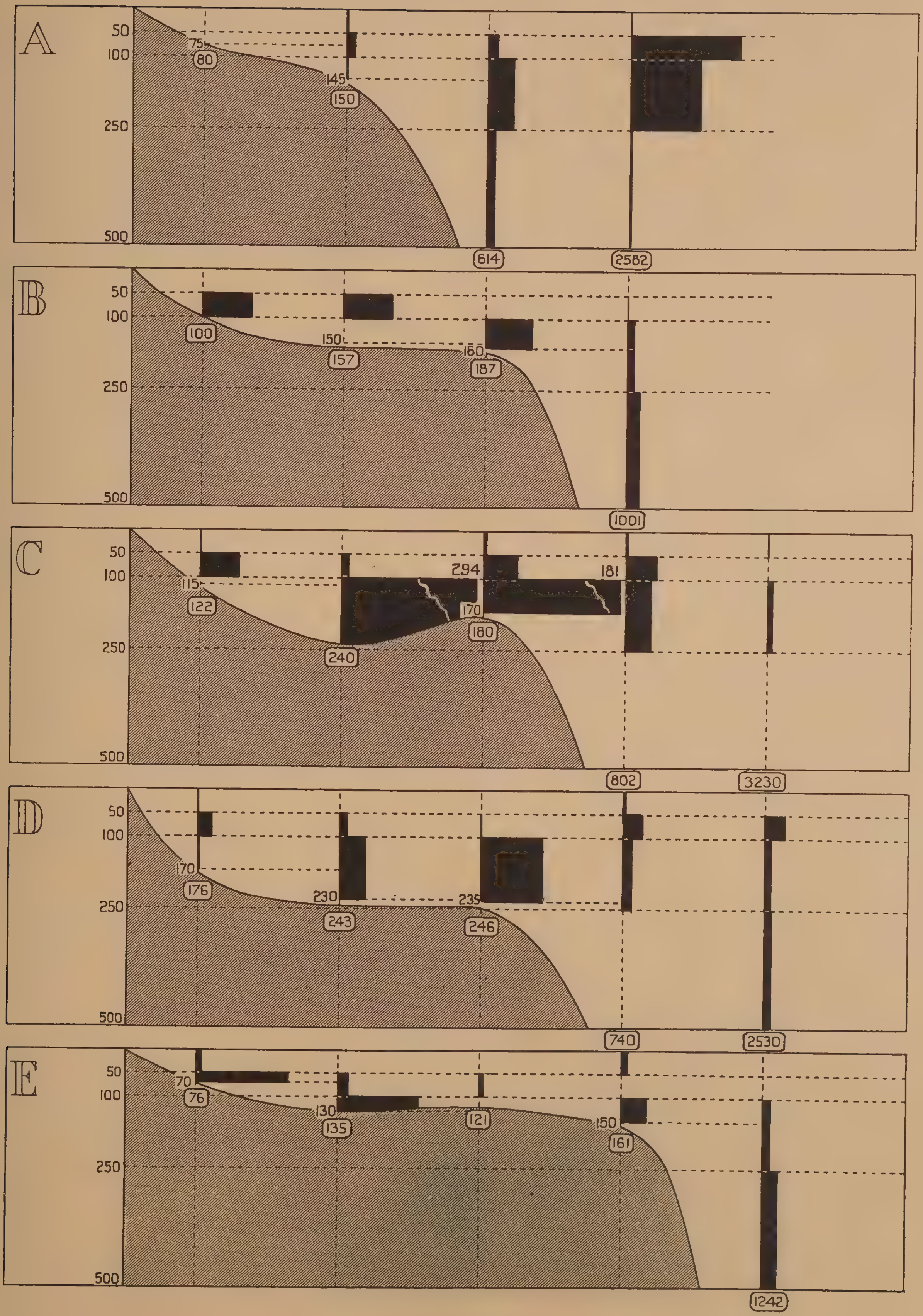


Fig. 68—*continued*

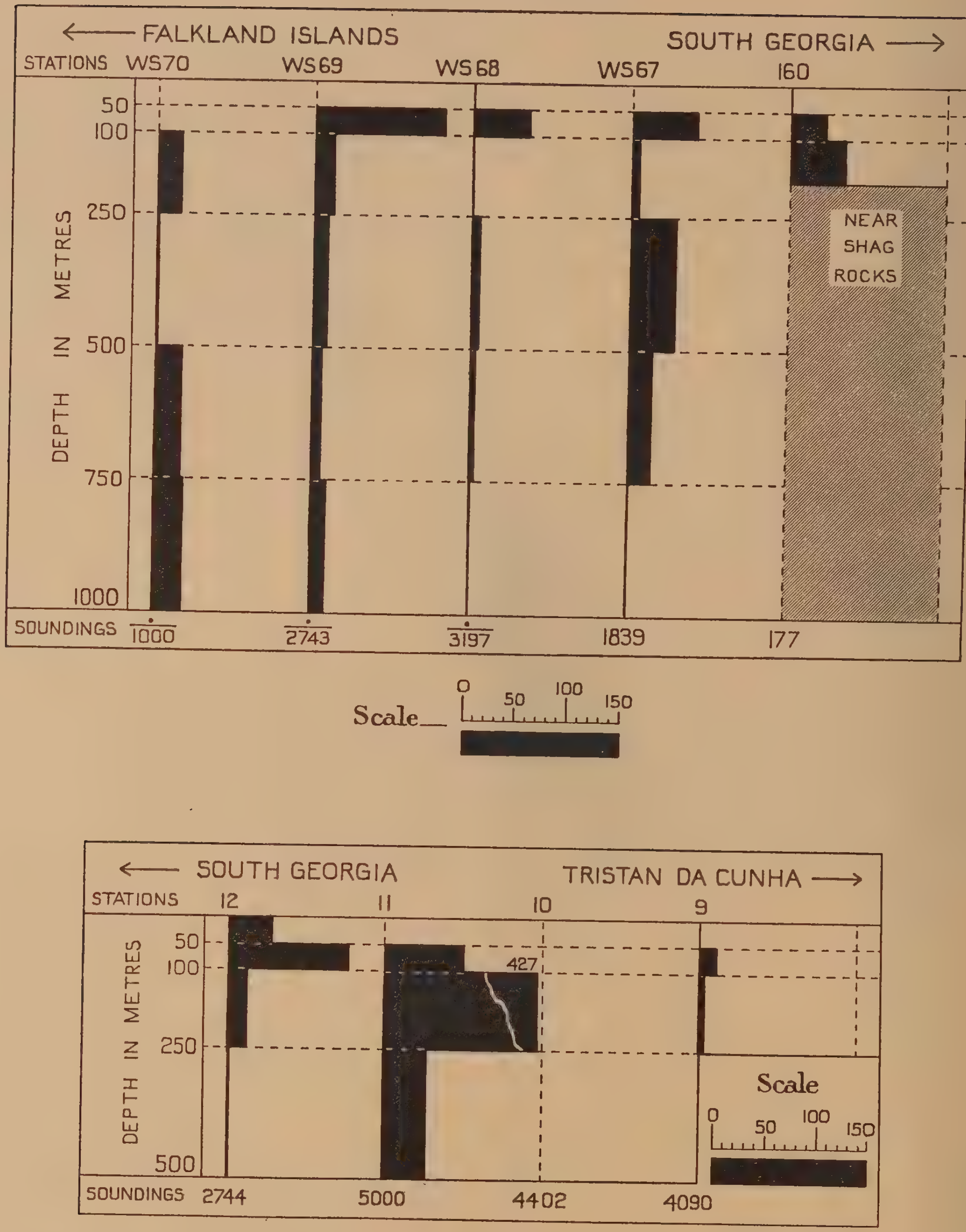


Fig. 69. Showing the vertical distribution of *Rhincalanus gigas* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.

R. gigas has been taken also by the Belgica,[1] Gauss,[2] Scotia[3] and Aurora[4] Expeditions.

Rhincalanus nasutus, Giesbr. Taken at three stations in water which is a mixture of the cold Antarctic surface layer and the warmer intermediate layer.

St. 124	103	at	210–100 m.	St. 138	18	at	250–100 m.
St. 132	1 ♀	at	170–0 m.		35	at	500–250 m.

Not previously recorded in the Antarctic Zone. It was found to be common by the 'Terra Nova'[5] off the north-west of New Zealand but not taken south of 34° 38′ S, see note in relation to *R. gigas* on p. 140.

Rhincalanus sp.

St. 133	5	at	500–250 m.	St. 137	3	at	50–0 m.
	1	at	750–500 m.	St. 139	1	at	50–0 m.

Calocalanus styliremis, Giesbr. Not taken in the Antarctic Zone proper, it was found only at Sts. 9 and 10 on the line approaching South Georgia from Tristan da Cunha in February 1926.

St. 9	N 70 V	6 ♀	at	50–0 m.	St. 10	N 70 V	2 ♀	at	50–0 m.

It was found to be common off New Zealand by the 'Terra Nova'.[5]

Clausocalanus arcuicornis (Dana). Of general distribution, but rarely abundant, it was taken in the N 70 V nets at the following stations and depths, extending from below 750 m. to the surface.

St. 9	3 ♀	at	50–0 m.	St. 17	50	at	250–100 m.
	5 ♀	at	100–50 m.	St. 124	10 ♀	at	100–50 m.
	27	at	250–100 m.		44 ♀	at	210–100 m.
St. 11	3 ♀	at	50–0 m.	St. WS 22 ...	5 ♀	at	100–50 m.
	87 ♀	at	100–50 m.	St. WS 29 ...	2 ♀	at	50–0 m.
	80	at	250–100 m.	St. WS 67 ...	37 ♂	at	1000–750 m.
	495	at	500–250 m.		75 ♀	at	1000–750 m.
St. 12	370	at	100–50 m.	St. WS 68 ...	119 ♀	at	50–0 m.
	1882	at	250–100 m.		7 ♀	at	100–50 m.
	361	at	500–250 m.	St. WS 69 ...	75 ♀	at	50–0 m.
St. 13	120	at	100–135 m.	St. WS 70 ...	395 ♀	at	1000–750 m.
St. 16	189 juv.	at	100–50 m.	St. WS 113 ...	2 ♀	at	100–50 m.
	30 ♀	at	250–100 m.				

It was taken by the 'Terra Nova'[5] as far as 76° S.

Clausocalanus laticeps, Farran. Also of general distribution, but more abundant than *C. arcuicornis*. A complete record of its occurrence is given in Appendix II. It was found at depths below 500 m. only at Sts. WS 69 and WS 70 approaching the Falkland Islands. It was taken in moderate numbers by the 'Terra Nova'[5] at or near the surface to the south of New Zealand between 51° 47′ S and 64° 03′ S.

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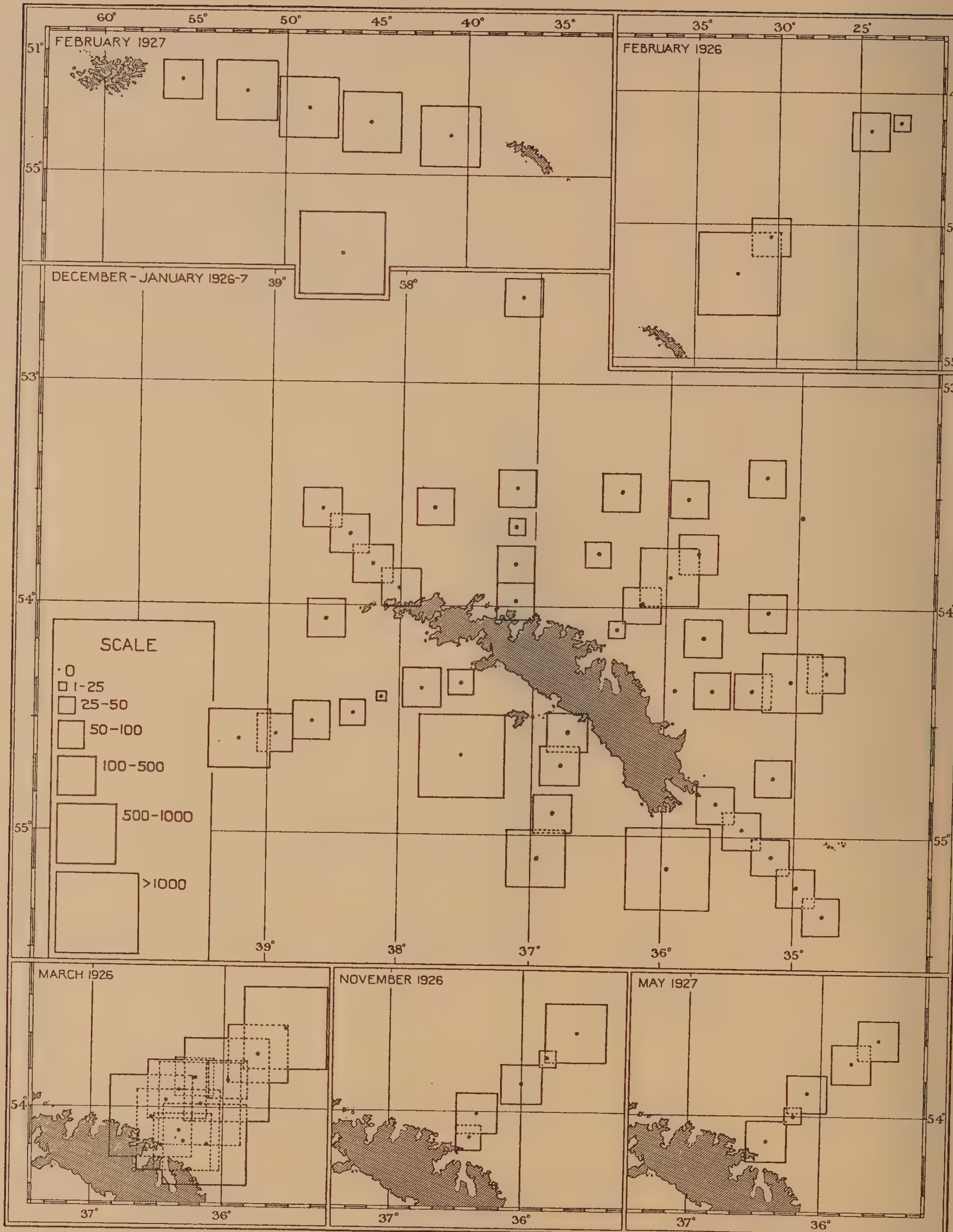
[1] Giesbrecht (1902).
[2] Wolfenden (1911).
[3] Scott (1912).
[4] Brady (1918).
[5] Farran (1929).


FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
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55°
DECEMBER-JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
·0
□ 1-25
25-50
50-100
100-500
500-1000
>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
37°
36°
54°

Fig. 70. Charts showing the distribution of *Ctenocalanus vanus* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

Clausocalanus furcatus (Brady). Only recorded at four stations between South Georgia and the Falkland Islands.

St. WS 67 ...	37	at 1000–750 m.	St. WS 69 ...	1 ♀	at 50–0 m.
St. WS 68 ...	1 ♀	at 250–100 m.		12	at 1000–750 m.
			St. WS 70 ...	15	at 250–100 m.

St. WS 67 is only just inside the Antarctic Zone, and here it was taken in the warmer intermediate zone. It is not recorded elsewhere from the Antarctic Zone.

Ctenocalanus vanus, Giesbr. This species was abundant throughout our region, except at St. 9 far to the north of the Antarctic Convergence on the Tristan-South Georgia line, and in somewhat reduced numbers at St. WS 70 towards the Falkland Islands. The reduction on these lines is clearly shown in Fig. 72. That we should find it abundant beyond the line of Convergence at Sts. WS 68 and WS 69 is not surprising after reading Farran's (1929) account of the species in his report on the Terra Nova collections. He writes that it was "taken in abundance off Rio de Janeiro and continuously in large numbers from off the north of New Zealand to the most southerly point reached".

The complete record of its occurrence is tabulated in Appendix II. For the December–January South Georgia survey, 1926–7, the average number per 50 m. haul with the N 70 V net in the top 250 m. of water was 288. It was more abundant over deep water than in the shallow coastal regions. The maximum number per 50 m. haul was 4029. Its general distribution is shown in Fig. 70. At the "control" St. 41 (see p. 265) the maximum number per 50 m. was 1445 and the minimum number 260; with this degree of irregularity in occurrence our charts can serve no more than to indicate its very general distribution. It is distributed equally in water of Bellingshausen Sea and Weddell Sea origin.

Its seasonal distribution, together with other forms, is discussed on p. 266; it occurred more abundantly in our samples taken in March 1926 than in those of November or December of the same year or of May in the following year.

Its vertical distribution round South Georgia is shown in Fig. 71, and that approaching South Georgia from the north-east in February 1926, and between South Georgia and the Falkland Islands in Fig. 72. It was most abundant in the top 100 m., but it has occurred in small numbers in waters as deep as 2000 and 1000 m. There is evidence of vertical migration, upwards at night; this, with the vertical migration of other forms, is discussed further on p. 236.

Its mean vertical distribution at deep water stations is shown in Fig. 55.

In addition to the Terra Nova, referred to above, the Belgica,[1] the National Antarctic (Discovery),[2] and the Gauss[3] Expeditions have recorded the species in large numbers in the Antarctic.

Microcalanus pygmaeus, G. O. Sars. Of general distribution but never abundant. It rarely occurred in shallow water, being as a rule confined to stations beyond the edge of the continental shelf. It occurred in the largest numbers at depths between 750 and 250 m., but was also taken between 2000 and 1000 m. See Fig. 55.

A complete record of its occurrence is tabulated in Appendix II.

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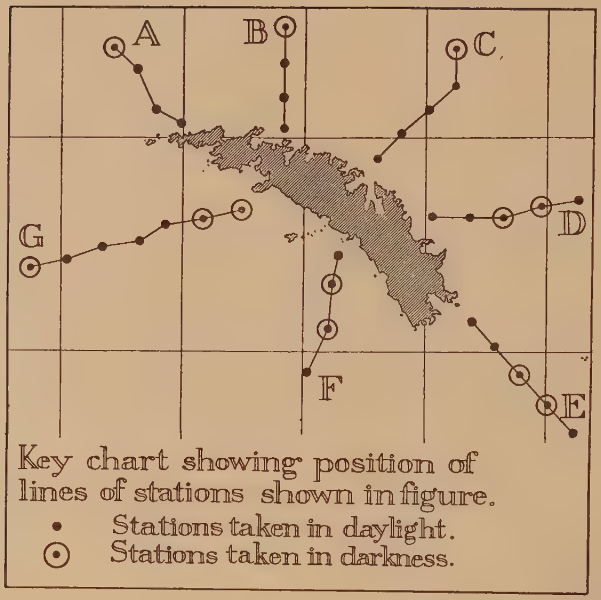
[1] Giesbrecht (1902).

[2] Wolfenden (1908).

[3] Wolfenden (1911).


A
B
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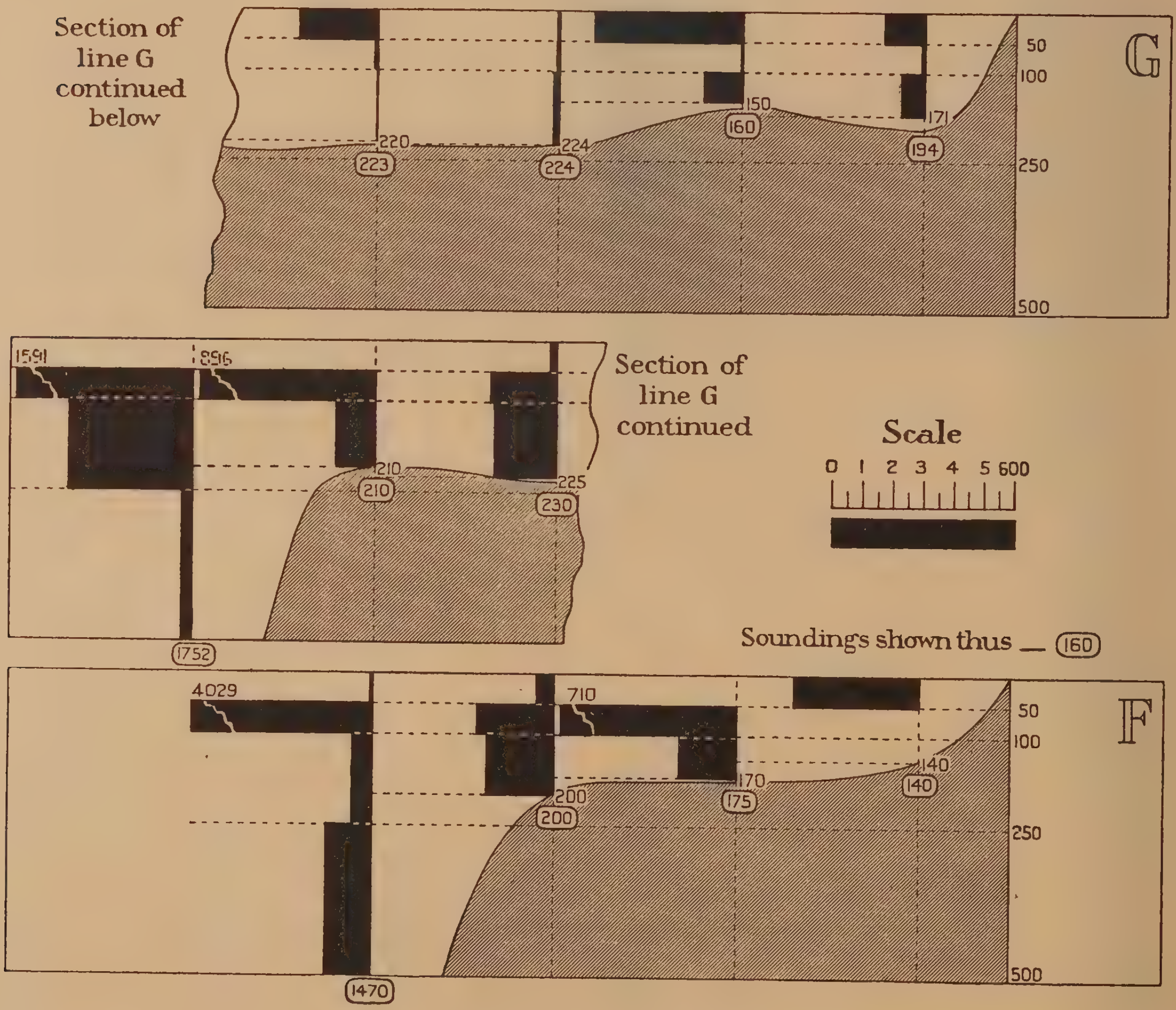
D
E
F
G
Key chart showing position of lines of stations shown in figure.
• Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 71. Showing the vertical distribution of **Ctenocalanus vanus**, Giesbr. down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



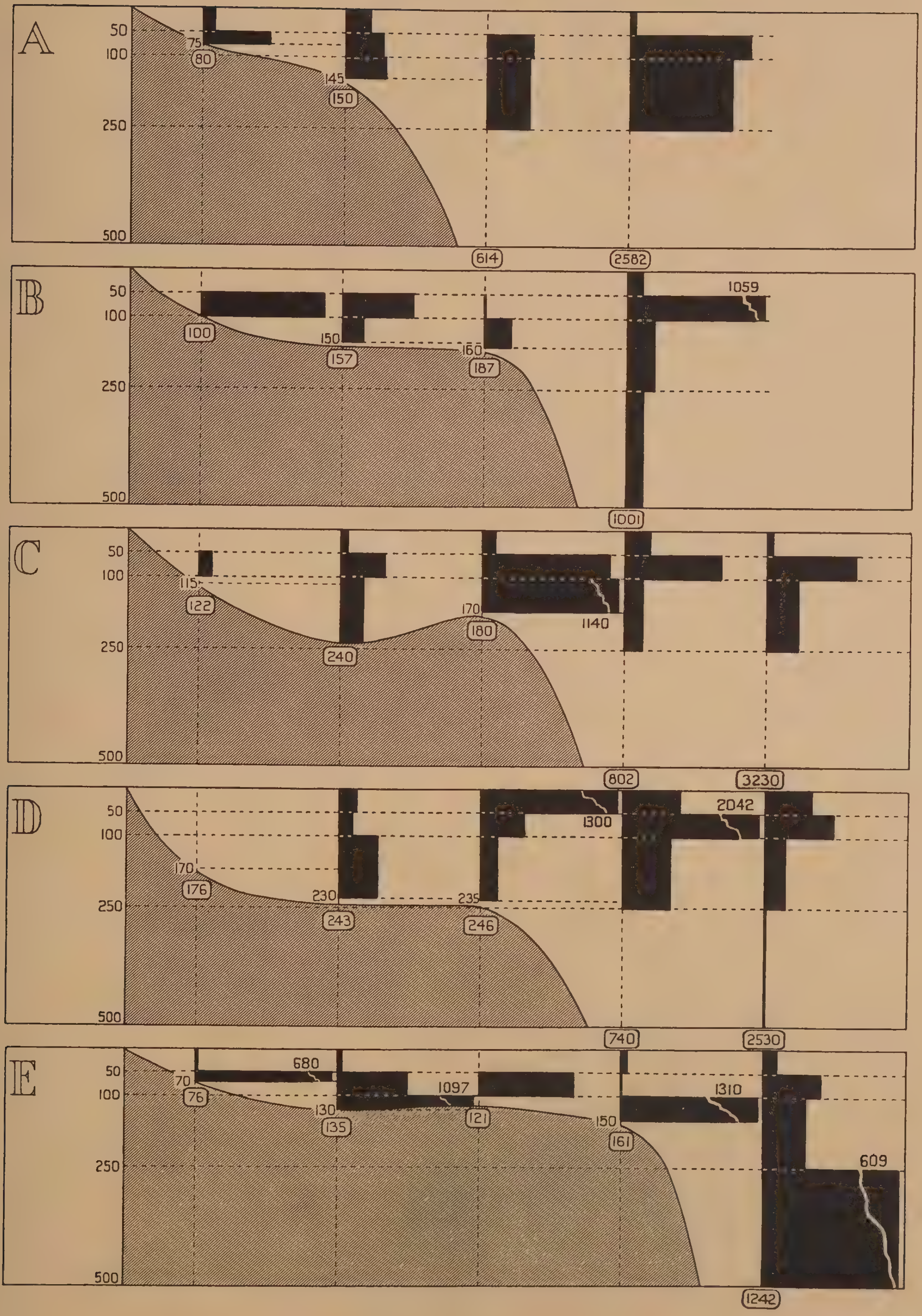


Fig. 71—*continued*

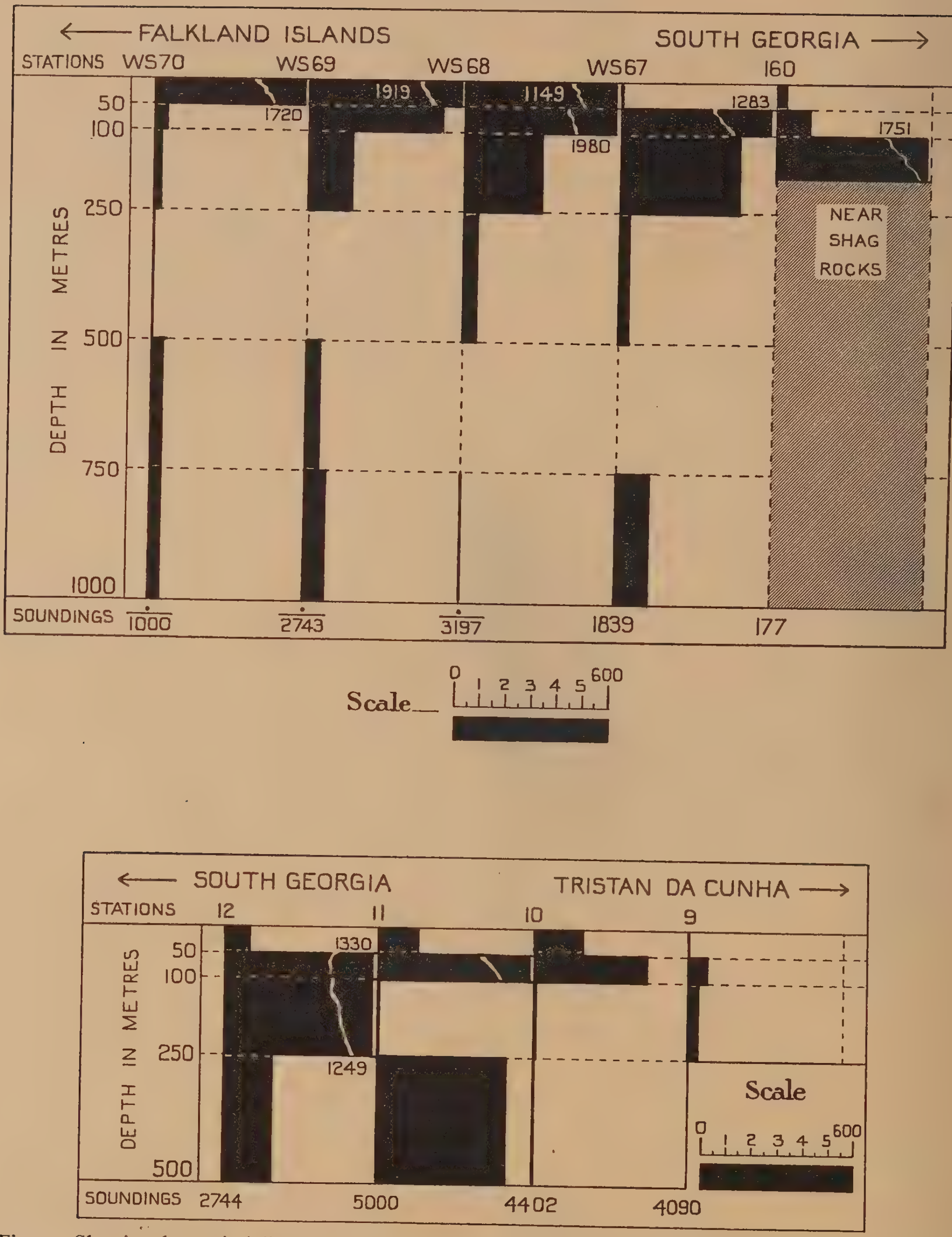
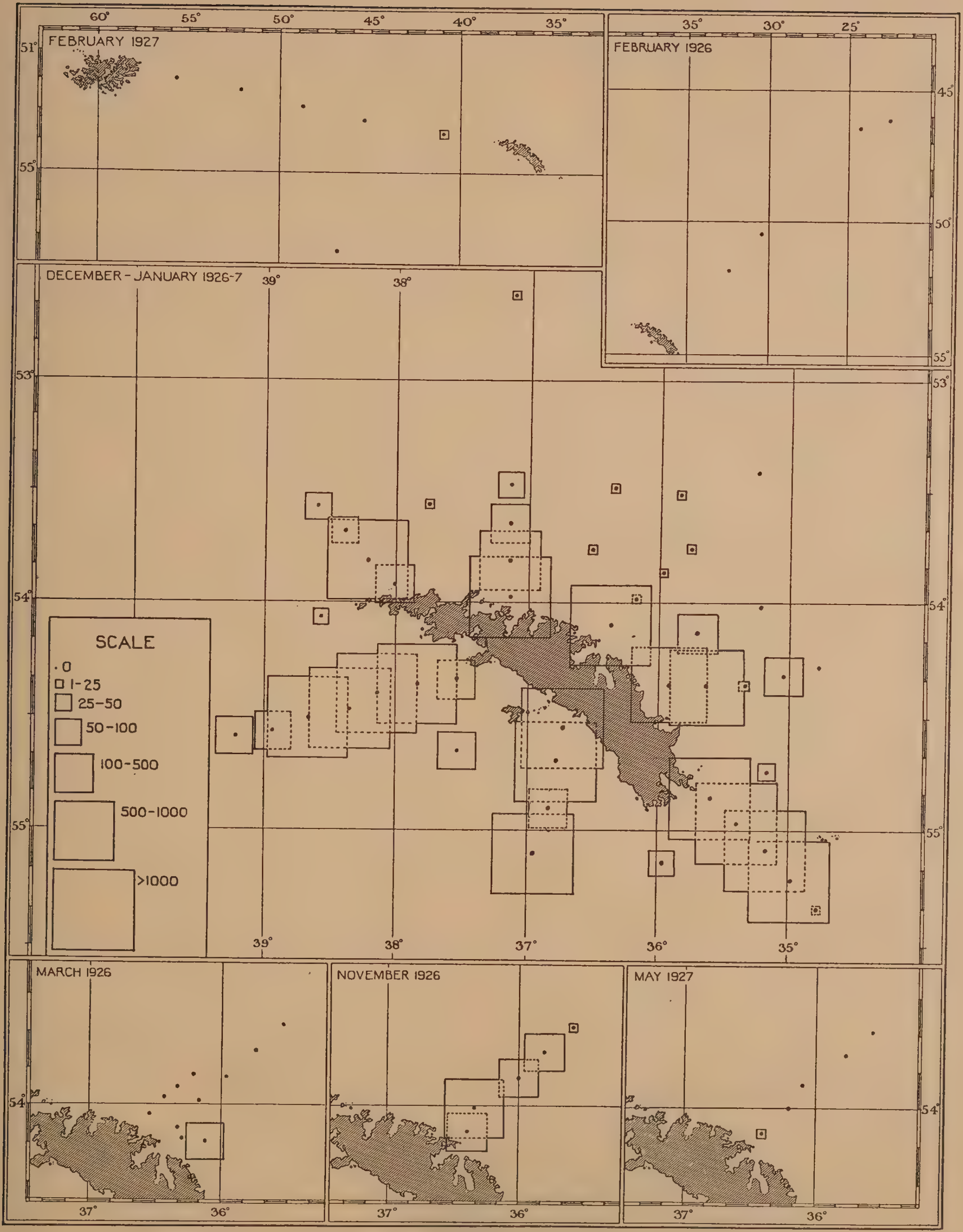


Fig. 72. Showing the vertical distribution of *Ctenocalanus vanus* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.


FEBRUARY 1927
60°
55°
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FEBRUARY 1926
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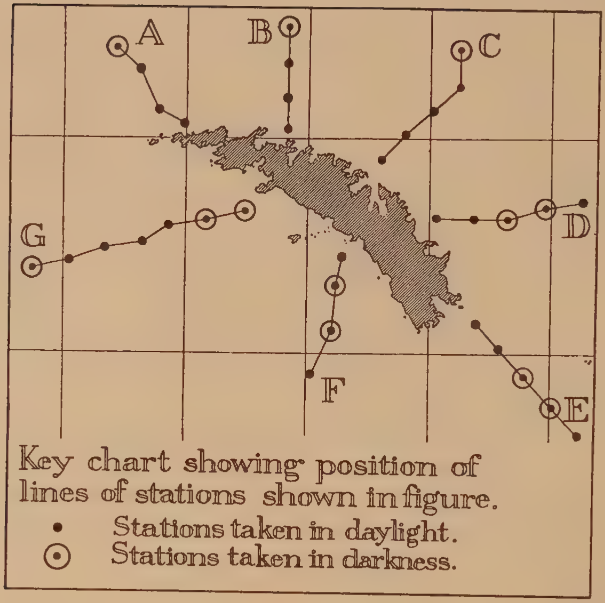
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
· 0
1-25
25-50
50-100
100-500
500-1000
>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
37°
36°
54°

Fig. 73. Charts showing the distribution of *Drepanopus pectinatus* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.


A
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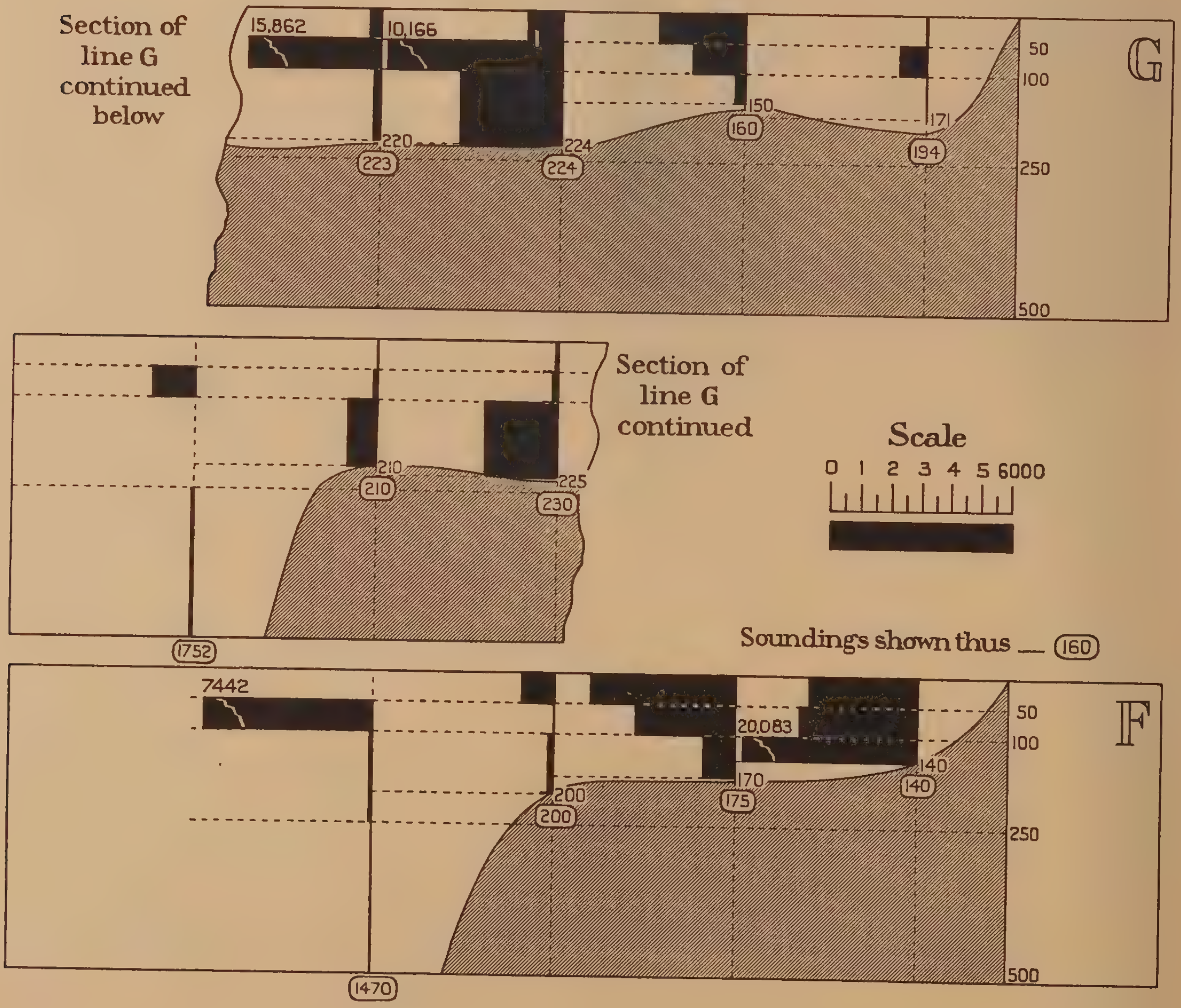
Key chart showing position of lines of stations shown in figure.
• Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 74. Showing the vertical distribution of **Drepanopus pectinatus**, Brady down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



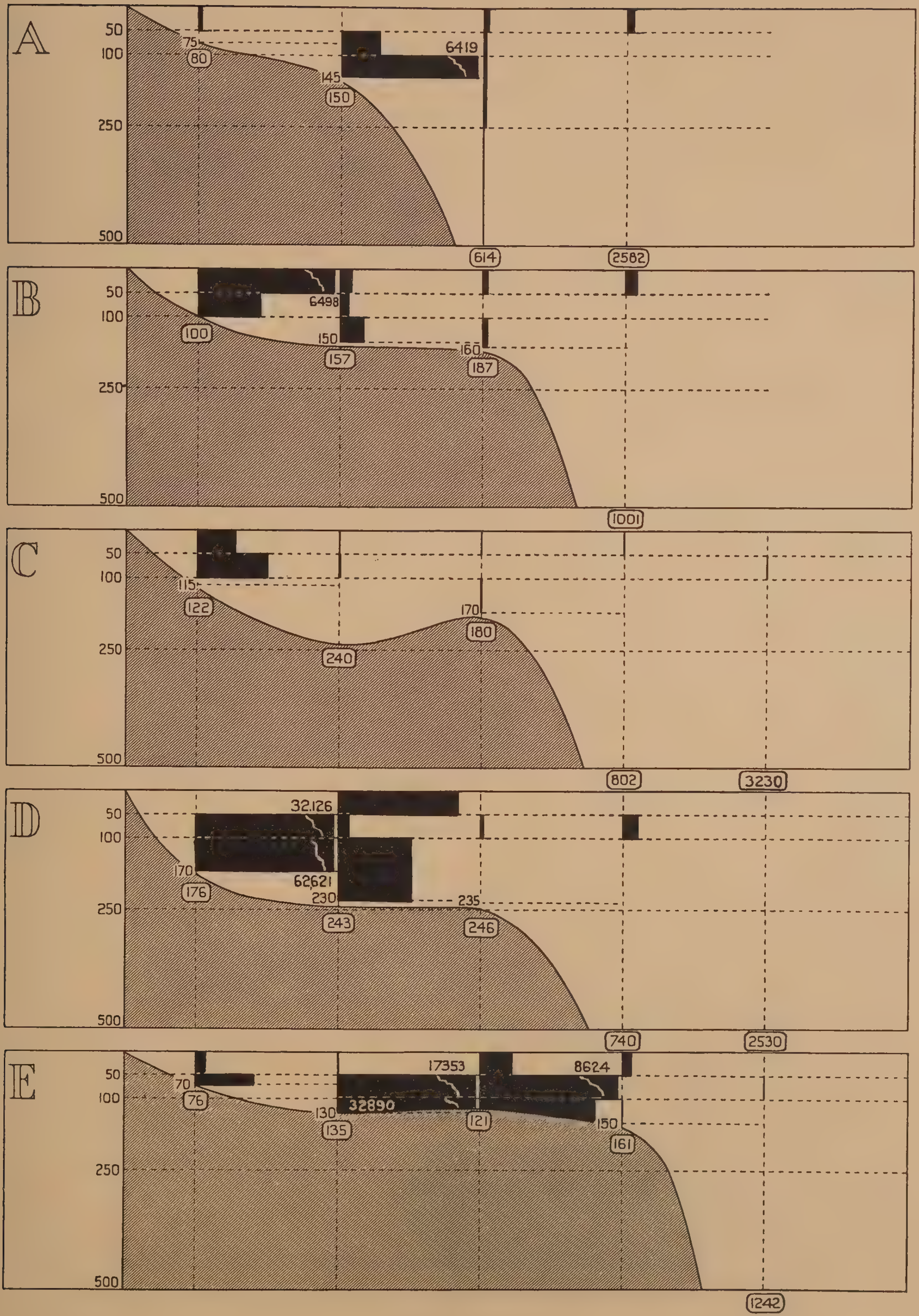


Fig. 74—*continued*

A few specimens of this species were taken by the 'Terra Nova'[1] through holes in the ice off Cape Evans 76–78° S.

Microcalanus sp.

St. 124	N 70 V	67 ♀	at	210–100 m.	St. 138	N 70 V	120 ♀	at	250–100 m.
St. 125	N 70 V	114	at	500–250 m.			1212 ♀	at	500–250 m.
		118	at	750–500 m.			206 ♀	at	750–500 m.
		715 ♀	at	1000–750 m.			172 ♀	at	1000–750 m.
St. 129	N 70 V	2314 ♀	at	500–250 m.	St. 151	N 70 V	11	at	750–500 m.
		765 ♀	at	750–500 m.			30	at	1000–750 m.
St. 131	N 70 V	1	at	50–0 m.	St. 161	N 70 V	29	at	500–250 m.
St. 133	N 70 V	4	at	750–500 m.			6	at	750–500 m.
St. 137	N 70 V	5	at	750–500 m.	St. WS 38 ...	N 70 V	20	at	750–500 m.
							30	at	1000–750 m.

Drepanopus pectinatus, Brady. The complete record of its occurrence is tabulated in Appendix II. Except for two specimens taken at St. 160 it was confined to the waters immediately surrounding South Georgia, where it occurred over the continental shelf in very large numbers. It was particularly abundant close against the coast and comparatively scarce at the stations beyond the edge of the shelf. The maximum number taken per 50 m. haul with the N 70 V net was 62,600, a number greatly exceeded by a horizontal haul with the same net (N 70 H) at the surface at St. 42, when 280,000 were taken per 50 m. tow. Its distribution as found in the December–January survey, 1926–7, round South Georgia is shown in Fig. 73, but significance must only be attached to corroborative evidence from groups of stations and to very large differences in numbers, because it is so very "patchy" in its occurrence. At the "control" St. 41 (see p. 265) the maximum number per 50 m. haul was 2832, and the minimum number 651. It cannot be said to be more abundant on one coast than another.

Owing to its patchiness in distribution it would be unwise to attempt to draw conclusions as to its seasonal occurrence from the slender data available. It was all but absent from the five stations (C line) taken in May 1927, only eight specimens being taken at St. WS 113; but this may be of little significance since it was completely absent from a similar line of stations in March 1926, yet 18,000 were recorded from a station in the same month a little distance away (St. 30).

Its vertical distribution round South Georgia is shown in Fig. 74; see also Fig. 56. It rarely occurred at depths below 250 m. It showed a marked vertical migration which is discussed together with that of other forms on p. 236.

It is interesting that this species, so abundant at South Georgia, does not appear to have been recorded in the Antarctic Zone before.

Spinocalanus abyssalis, var. *pygmaeus*, Farran. This species only occurred in the deep water of the intermediate layer, or at St. 138 possibly extending into the cold bottom layer below 1500 m.

St. 129... ...	22	at	950–780 m.	St. WS 30 ...	6 ♀	at	750–500 m.
St. 138... ...	25	at	2000–1000 m.				

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[1] Farran (1929).

Several specimens were taken by the 'Terra Nova'[1] in the deeper vertical hauls—below 400 m.—between 66° 30′ and 76° S.

Spinocalanus horridus, Wolf.

St. 138... ... 25 at 2000–1000 m.

This species has not been recorded in the Antarctic Zone before.

Spinocalanus magnus, Wolf.

St. 138	6 juv.	at	2000–1000 m.	St. WS 30	6 ♀	at	750–500 m.

Several specimens were taken by the 'Gauss'[2] north-west of their winter quarters in deep water, approx. 66° S.

Spinocalanus sp.

St. 138	6 ♀	at	2000–1000 m.	St. WS 38	15	at	1000–750 m.
St. 151	1 ♀	at	750–500 m.	St. WS 63	1	at	1000–750 m.
	3	at	1000–750 m.	St. WS 67	1 ♀	at	1000–300 m.
St. WS 22	15	at	750–500 m.				

Aetidius armatus (Boeck). Was taken both north and south of the Antarctic Convergence. It was taken in the intermediate layer or a mixture of this water and the cold surface layer, occasionally being taken almost in the cold surface layer.

St. 9	N 70 V	5 juv.	at	100–50 m.	St. WS 36	N 70 H	1	at	67 m.
		6 juv.	at	250–100 m.	St. WS 38	N 70 V	1 juv.	at	1000–750 m.
St. 11	N 70 V	254	at	250–100 m.	St. WS 40	N 70 H	5	at	108 m.
		66	at	500–200 m.	St. WS 47	N 70 V	1 juv.	at	150–100 m.
St. 17	N 70 V	11 ♀	at	250–100 m.	St. WS 54	N 70 V	22 ♀	at	500–250 m.
St. 125	N 70 V	4 ♀	at	250–100 m.	St. WS 61	N 70 V	1 ♀	at	1000–750 m.
		7	at	500–250 m.	St. WS 61	N 70 H	3	at	159 m.
St. 134	N 70 H	2	at	120 m.	St. WS 67	N 70 V	1 ♀	at	250–100 m.
St. 137	N 70 V	5	at	700–500 m.			1 ♀	at	1000–300 m.
St. 138	N 70 V	6 ♀	at	500–250 m.	St. WS 68	N 70 V	42 ♀ juv.	at	100–50 m.
		1 ♀	at	2000–1000 m.			182 ♀	at	250–100 m.
St. 151	N 70 V	3 juv.	at	1000–750 m.			1	at	500–250 m.
St. WS 18	N 70 H	1	at	128 m.	St. WS 69	N 70 V	103	at	250–100 m.
St. WS 20	N 70 H	2	at	164 m.			3 ♀	at	500–250 m.
St. WS 20	N 70 V	28	at	250–100 m.	St. WS 70	N 70 V	1 ♀	at	750–500 m.
St. WS 22	N 70 V	6 ♀	at	1000–750 m.			1 ♀	at	1000–750 m.
St. WS 36	N 70 V	52	at	500–250 m.	St. WS 111	N 70 V	1 ♀	at	500–250 m.
		4	at	750–500 m.	St. WS 112	N 70 H	1	at	154 m.

Specimens were taken by the 'Aurora'[3] at Macquarie Islands.

Gaidius intermedius, Wolf. A single female specimen was taken at St. 138 between 2000 and 1000 m. depth. The division between the intermediate layer and the cold Antarctic bottom layer occurs at about 1500 m. This species was taken by the 'Terra Nova'[1] from two deep-water hauls (1760–1000 m.) at 66° 30′ S and 76° S.

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[1] Farran (1929).

[2] Wolfenden (1911).

[3] Brady (1918).

Gaidius tenuispinus (Sars). Of general distribution in the deeper water, but never abundant.

St. 12	N 70 V	1 ♀	at	500–250 m.
St. 17	N 70 V	2 ♀	at	250–100 m.
		1 ♀	at	500–250 m.
		1 ♂	at	500–250 m.
		1 juv.	at	500–250 m.
St. 124	N 70 V	1 juv.	at	210–100 m.
St. 125	N 70 V	2	at	500–250 m.
		17 ♀	at	750–500 m.
		1 juv.	at	1000–750 m.
St. 129	N 70 V	4 ♀	at	500–250 m.
		16 ♀	at	750–500 m.
		1 ♂	at	750–500 m.
		2 ♀	at	950–780 m.
St. 133	N 70 V	2 ♀	at	750–500 m.
St. 137	N 70 V	6 ♀	at	250–100 m.
		4 ♀	at	500–250 m.
		7	at	700–500 m.
St. 138	N 70 V	1 juv.	at	1000–750 m.
St. 139	N 70 V	1 juv.	at	250–170 m.
St. 151	N 70 V	12	at	750–500 m.
		9	at	1000–750 m.
	N 100 H	41	at	500–625 m.
St. 161	N 70 V	5	at	500–250 m.
		7	at	750–500 m.
		2	at	1000–750 m.
St. WS 20 ...	N 70 V	1 ♀	at	500–250 m.
		1 juv.	at	500–250 m.
St. WS 22 ...	N 70 V	14	at	500–250 m.
		1 ♀	at	750–500 m.
		3 juv.	at	750–500 m.
		1 ♀	at	1000–0 m.
		5	at	1000–750 m.
St. WS 26 ...	N 70 V	1	at	750–0 m.
		5	at	750–500 m.
		2 ♀	at	1000–750 m.
St. WS 29 ...	N 70 V	2	at	600–500 m.
St. WS 30 ...	N 70 V	3 ♀	at	500–250 m.
		25	at	500–330 m.
		5	at	750–500 m.
		2	at	1000–750 m.
St. WS 35 ...	N 70 V	1	at	150–100 m.
St. WS 36 ...	N 70 V	24	at	750–500 m.
		1 ♂	at	1000–750 m.
		2 juv.	at	1000–750 m.
St. WS 38 ...	N 70 V	3	at	500–250 m.
		16	at	750–500 m.
		1 ♀	at	1000–750 m.
St. WS 44 ...	N 70 V	3	at	500–250 m.
		10 ♀	at	750–500 m.
		8 juv.	at	750–500 m.
St. WS 54 ...	N 70 V	22 ♀	at	500–250 m.
St. WS 61 ...	N 70 V	2	at	500–250 m.
		16 ♀	at	750–500 m.
		3	at	1000–750 m.
St. WS 63 ...	N 70 V	1 ♀	at	500–250 m.
		4 ♀	at	750–500 m.
St. WS 67 ...	N 70 V	2 juv.	at	500–250 m.
		2 ♀	at	750–500 m.
		1 juv.	at	750–500 m.
		1 ♀	at	1000–750 m.
		18	at	1000–300 m.
St. WS 68 ...	N 70 V	5	at	500–250 m.
		4	at	750–500 m.
St. WS 69 ...	N 70 V	6 ♀	at	750–500 m.
		15	at	1000–750 m.
St. WS 70 ...	N 70 V	4 ♀	at	500–250 m.
		1 ♀	at	750–500 m.
		5 ♀	at	1000–750 m.
St. WS 110 ...	N 70 V	2 juv.	at	500–300 m.
		1 ♀	at	1000–750 m.
		49 juv.	at	1000–750 m.
St. WS 111 ...	N 70 V	3 juv.	at	250–100 m.
		3 juv.	at	500–250 m.
		5 juv.	at	750–500 m.
		1 juv.	at	1000–750 m.
St. WS 112 ...	N 100 H	1 ♀	at	136 m.

It was frequently taken by the 'Terra Nova'[1] from depths of 500–1750 m. in the Antarctic (66° 30′–76° S).

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[1] Farran (1929).

Gaidius sp.

St. 17 ... ... 1 juv. at 250–100 m.
1 at 500–250 m.
St. 138 ... ... 5 ♀ at 2000–1000 m.
St. 151 ... ... 4 at 1000–750 m.
St. 161 ... ... 1 at 1000–750 m.
St. WS 30 ... 1 ♀ at 500–250 m.
St. WS 44 ... 3 ♀ at 750–500 m.
St. WS 44 ... 2 ♀ at 1000–750 m.
St. WS 54 ... 1 ♀ at 500–250 m.
St. WS 61 ... 1 at 750–500 m.
1 at 1000–750 m.
St. WS 63 ... 5 juv. at 1000–750 m.
St. WS 68 ... 1 ♀ at 1000–750 m.

Drepanopsis frigidus, Wolf. Was taken from the intermediate layer at these stations in the Antarctic Zone.

St. 138 ... ... 17 ♀ at 1000–750 m.
St. 161 ... ... 1 ♀ at 1000–750 m.
St. WS 67 ... 12 ♀ at 1000–300 m.

It was taken by the 'Terra Nova'[1] in three vertical hauls 600–0, 1000–0, and 1750–0 m. between 66° 30′ and 76° S, and was also taken by the 'Gauss'[2] near their winter headquarters at approx. 66° S.

Pseudochirella notacantha, G. O. Sars. A single male specimen taken in the intermediate layer at St. 138 at 1000–750 m. Two specimens of this species were taken by the 'Terra Nova'[1] in vertical hauls from 1000 and 1760 m. at 66° 30′ and 76° S.

Pseudochirella pustulifera, G. O. Sars. Two specimens were taken from the intermediate layer.

St. WS 44 ... 1 ♀ at 750–500 m.
St. WS 67 ... 1 ♀ at 1000–300 m.

This species has not before been taken in the Antarctic Zone.

Gaetanus antarcticus, Wolf. A single immature specimen taken at St. 67 in a haul from 1000 to 300 m. It has before been recorded from the Antarctic by the National Antarctic ('Discovery'),[3] 'Gauss'[2] and 'Terra Nova'.[1]

Undeuchaeta major, Giesbr. Was taken from two stations in the sub-Antarctic Zone towards the Falkland Islands.

St. WS 69 ... 1 juv. at 100–50 m.
1 juv. at 250–100 m.
St. WS 69 ... 2 juv. at 750–500 m.
St. WS 70 ... 2 ♀ at 500–250 m.

It was not taken by us in the Antarctic Zone proper, but the 'Terra Nova'[1] obtained a specimen in a surface haul from as far south as 68° 37′ S.

Euchirella hirsuta, Wolf. Two female specimens were taken at St. 138 at 2000–1000 m. At this station the division between the intermediate layer and the cold deep Antarctic layer is at approximately 1500 m. It was taken by the 'Terra Nova'[1] and the 'Gauss'[2] in the Antarctic.

Euchirella rostrata (Claus). This species was widely distributed in the area, usually in the layer of mixed water between the cold surface layer and the warmer intermediate layer. It only occurred in the top 50 m. at St. WS 70 in the sub-Antarctic Zone. It occasionally occurred below 750 m.

[1] Farran (1929).
[2] Wolfenden (1911).
[3] Wolfenden (1908).

St. 12	N 70 V	1 ♀ at	500–250 m.
St. 17	N 70 V	1 ♀ at	500–250 m.
St. 32	N 100 H	1 ♀ at	90(–0) m.
St. 36	N 100 H	50 at	90(–0) m.
St. 37	N 100 H	128 at	90(–0) m.
St. 41 A	N 70 V	1 ♀ at	265–150 m.
St. 41 B	N 70 V	2 ♀ at	250–150 m.
St. 41 C	N 70 V	2 ♀ at	240–150 m.
St. 41 D	N 70 V	3 ♀ at	240–150 m.
St. 125	N 70 V	1 juv. at	250–100 m.
St. 128	N 70 V	1 juv. at	160–100 m.
St. 129	N 70 V	1 juv. at	250–100 m.
St. 131	N 100 H	1 ♀ at	128 m.
St. 139	N 100 H	4 ♀ at	90 m.
		6 juv. at	90 m.
St. 151	N 70 V	2 juv. at	500–250 m.
	N 100 H	1 ♀ at	500–625 m.
		1 juv. at	500–625 m.
St. 160	N 70 V	1 at	180–100 m.
St. WS 19	N 100 H	2 ♀ at	164 m.
St. WS 20	N 70 V	2 ♀ at	500–250 m.
St. WS 26	N 70 V	1 ♀ at	500–250 m.
St. WS 26	N 70 H	3 ♀ at	140 m.
		4 juv. at	140 m.
St. WS 29	N 70 V	1 ♀ at	250–100 m.
		1 juv. at	500–250 m.
St. WS 30	N 100 H	1 ♀ at	134 m.
St. WS 38	N 70 V	1 ♀ at	500–250 m.
St. WS 44	N 70 V	1 ♀ at	750–500 m.
		1 juv. at	750–500 m.
St. WS 57	N 100 H	6 juv. at	132 m.
St. WS 60	N 100 H	3 juv. at	146 m.
St. WS 61	N 70 V	1 ♀ at	250–100 m.
		1 juv. at	250–100 m.
	N 100 H	2 ♀ at	132 m.
		20 juv. at	132 m.
St. WS 63	N 100 H	1 ♀ at	157 m.
St. WS 69	N 70 V	1 ♀ at	100–50 m.
		2 juv. at	100–50 m.
		1 ♀ at	750–500 m.
		1 ♀ at	1000–750 m.
St. WS 70	N 70 V	1 ♀ at	50–0 m.
		2 ♀ at	100–50 m.
		1 juv. at	250–100 m.

It was taken commonly off New Zealand by the 'Terra Nova'[1] and on two occasions in the Antarctic Zone.

Euchirella spinosa, Wolf. Was taken in deep water in the sub-Antarctic Zone.

St. WS 68 ... 1 juv. at 1000–750 m.

It is not an Antarctic species.

Euchirella spp. juv.

St. 124	N 100 H	3 at	180–90 m.
St. 138	N 100 H	5 at	155 m.
St. 139	N 100 H	2 at	180 m.
St. 161	N 70 V	1 at	1000–750 m.
St. WS 21	N 100 H	1 at	192 m.
St. WS 22	N 70 V	1 at	250–100 m.
	N 70 H	1 at	165 m.
	N 100 H	1 at	185 m.
St. WS 36	N 70 V	6 at	500–250 m.
		6 at	750–500 m.
St. WS 37	N 70 V	2 at	310–250 m.
St. WS 38	N 70 V	4 at	250–100 m.
St. WS 40	N 70 H	2 at	108 m.
St. WS 43	N 70 H	1 at	124 m.
St. WS 43	N 100 H	2 at	70 m.
		2 at	141 m.
St. WS 44	N 70 V	3 at	500–250 m.
St. WS 45	N 70 V	1 at	100–50 m.
St. WS 49	N 70 H	1 at	161 m.
St. WS 51	N 100 H	2 at	128 m.
St. WS 54	N 70 V	2 at	500–250 m.
St. WS 61	N 70 V	2 at	500–250 m.
St. WS 63	N 70 V	1 at	500–250 m.
St. WS 67	N 70 V	3 at	1000–300 m.
St. WS 69	N 70 V	1 at	250–100 m.
		4 at	750–500 m.
St. WS 70	N 70 V	3 at	1000–750 m.

Pareuchaeta antarctica, Giesbr. This species had a very general distribution throughout the area, but was never abundant. The complete record of its occurrence is tabulated in Appendix II. It was not caught in large numbers by the N 70 V net. Its distribution as shown by the N 100 H nets, towed horizontally at the surface, and approximately at 60 and 120 m., is shown in Fig. 75. Very few were taken between South Georgia and the Falkland Islands. As its name implies, it is a true Antarctic species; Farran (1929) in his report on the Terra Nova collections writes that it is "common from the Antarctic Circle southwards". It occurred in water of both Bellingshausen Sea and Weddell Sea origin, and was taken in the largest numbers in March 1926.

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[1] Farran (1929).

A study of the N 100 H net results revealed evidence of a distinct vertical migration—this is described and illustrated on pp. 236 and 247. One of the consecutive net series, described on p. 254, showed that it is somewhat patchy in its distribution.

In addition to the 'Terra Nova' referred to above, it was taken in the Antarctic by the Belgica,[1] Pourquoi-Pas?,[2] Gauss[3] and Aurora[4] Expeditions.

Pareuchaeta farrani (With.).

St. WS 67 ... 1 ♀ at 1000–300 m.

A single specimen of this Copepod was taken by the 'Terra Nova'[5] in a vertical haul for 1000 m. within the Antarctic Circle.

Pareuchaeta biloba, Farran. Was taken in the intermediate layer at a number of stations round South Georgia as well as at St. 70 north of the Antarctic Convergence.

St. 125	1 ♀	at	750–500 m.	St. WS 36 ...	2 ♂, 2 ♀	at	750–500 m.
	1 ♀	at	1000–750 m.	St. WS 44 ...	2 ♀	at	1000–750 m.
St. 129	1 ♂, 1 ♀	at	500–250 m.	St. WS 67 ...	1 ♀	at	500–250 m.
	1 ♂, 2 ♀	at	750–500 m.	St. WS 70 ...	1 ♀	at	500–250 m.
St. WS 22 ...	1 ♂, 2 ♀	at	1000–750 m.	St. WS 70 ...	1 ♀	at	750–500 m.
St. WS 26 ...	1 ♀	at	500–250 m.		2 ♂, 2 ♀	at	1000–750 m.
	2 ♀	at	750–0 m.				

The 'Terra Nova'[5] took a single specimen in a surface haul within the Antarctic Circle.

Pareuchaeta scotti, Farran. Was confined to the intermediate layer.

St. 129	N 70 V	1 ♀	at	950–780 m.	St. WS 26 ...	N 70 V	3 ♀	at	1000–750 m.
St. 137	N 70 V	1 ♂, 1 ♀	at	700–500 m.	St. WS 36 ...	N 70 V	1	at	1000–750 m.
St. 151	N 100 H	1 ♂, 4 ♀	at	500–625 m.	St. WS 44 ...	N 70 V	4 ♀	at	1000–750 m.
St. 161	N 70 V	1 ♀	at	1000–750 m.			3 juv.	at	1000–750 m.
St. WS 22 ...	N 70 V	1 ♀	at	750–500 m.	St. WS 61 ...	N 70 V	1 ♀	at	1000–750 m.
		2 juv.	at	750–500 m.			1 juv.	at	1000–750 m.
		2 ♀	at	1000–0 m.	St. WS 63 ...	N 70 V	2 ♀	at	1000–750 m.
		4 juv.	at	1000–0 m.	St. WS 67 ...	N 70 V	1 ♂, 2 ♀	at	1000–300 m.
St. WS 26 ...	N 70 V	1 ♀	at	750–0 m.	St. WS 111 ...	N 70 V	1 ♀	at	750–500 m.
		2 ♀	at	750–500 m.			2 juv.	at	750–500 m.

This species has not previously been recorded from the Antarctic Zone.

Pareuchaeta sp.

St. 17	1	at	750–500 m.	St. 138	1 ♀, 1 ♂	at	2000–1000 m.
St. 138	2	at	1000–750 m.	St. WS 63 ...	1 ♀	at	750–500 m.

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[1] Giesbrecht (1902). [2] Quidor (1906). [3] Wolfenden (1911). [4] Brady (1918). [5] Farran (1929).

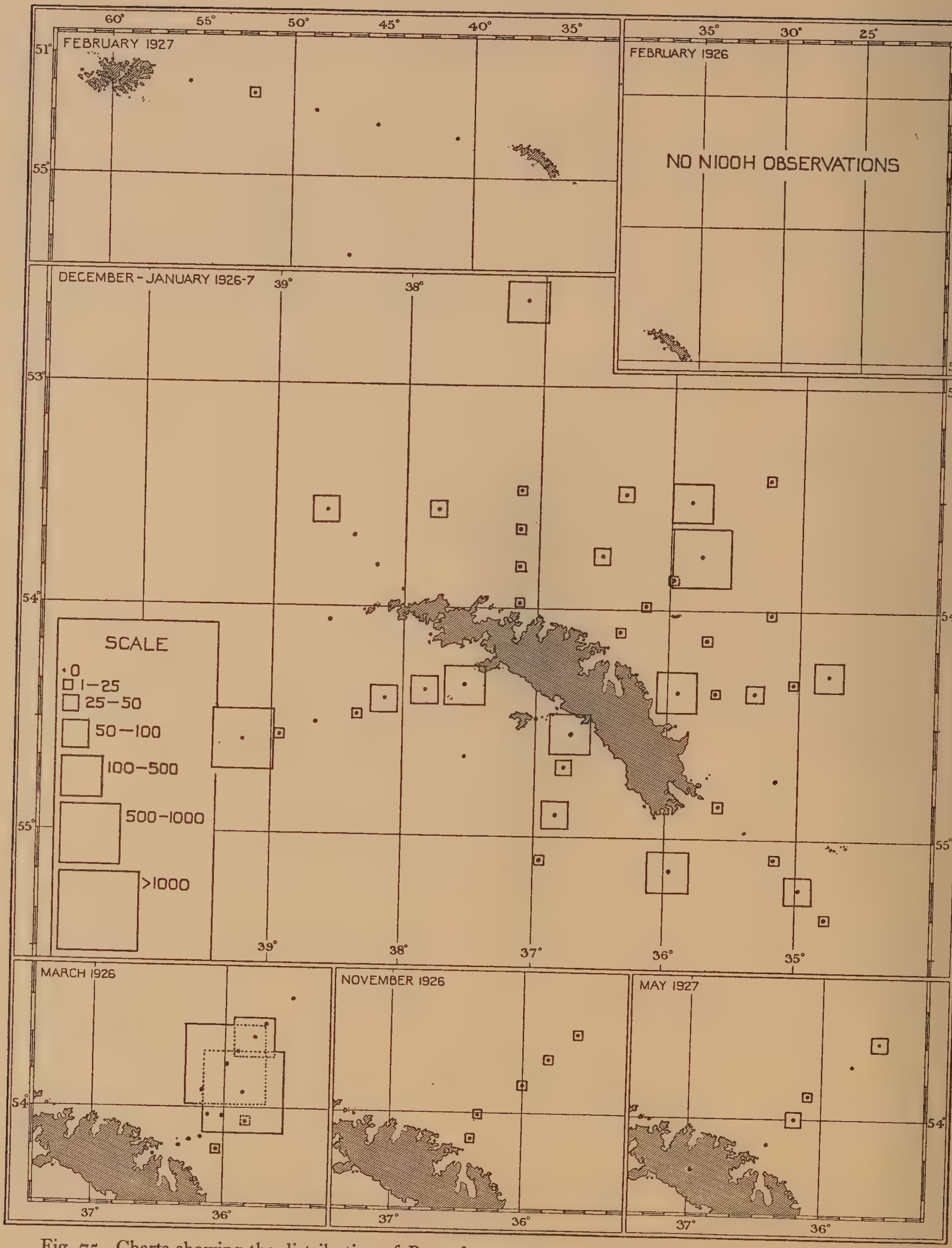
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
NO N100H OBSERVATIONS
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
• 0
1–25
25–50
50–100
100–500
500–1000
>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 75. Charts showing the distribution of *Pareuchaeta antarctica* at stations in the 1926–7 surveys. The squares represent the numbers taken in three N 100 H nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

Pareuchaeta spp. juv. are recorded in Appendix II.

Xanthocalanus gracilis, Wolf.

St. 138... ... 1 ♀, 21 juv. at 2000–1000 m.

At this station the division between the intermediate layer and the deep Antarctic layer occurred at about 1500 m. This Copepod was taken by the Gauss[1] Expedition at their winter quarters in 66° S.

Onchocalanus cristatus, Wolf. This species was taken in the intermediate layer at stations in the Antarctic Zone, and near the surface only at St. 70 north of the Antarctic Convergence.

St. 129... ... 1 ♀ at 950–780 m.
St. 138... ... 2 ♀ at 2000–1000 m.
9 ♀ at 1000–750 m.
St. WS 63 ... 1 ♀ at 750–500 m.
St. WS 67 ... 2 ♀ at 1000–750 m.
St. WS 68 ... 1 ♀ at 1000–750 m.
St. WS 70 ... 1 ♀ at 250–100 m.

It has not previously been recorded in the Antarctic Zone.

Onchocalanus magnus, Wolf.

St. 138... ... 1 ♀ at 1000–750 m.
St. WS 26 ... 1 ♀ at 750–500 m.
St. WS 26 ... 1 juv. at 750–500 m.
1 ♀ at 1000–750 m.

It was taken in the Antarctic by the 'Gauss'.[1]

Onchocalanus sp.

St. 138... ... 10 at 2000–1000 m.

Onchocalanus spp. juv.

St. 138... ... 6 at 2000–1000 m.
St. WS 22 ... 1 at 1000–0 m.
St. WS 44 ... 2 at 750–500 m.
St. WS 44 ... 1 ♀ at 1000–750 m.
St. WS 61 ... 1 ♀ at 750–100 m.

Cornucalanus magnus, Wolf.

St. WS 26 ... 1 ♀ at 500–250 m.

Not previously recorded in the Antarctic Zone.

Cephalophanes frigidus, Wolf.

St. WS 44 ... 9 juv. at 750–500 m.
1 at 1000–750 m.

It was taken in the Antarctic by the Gauss[1] and Terra Nova[2] Expeditions.

Cephalophanes sp.

St. WS 67 ... 14 juv. at 1000–300 m.

Scolecithrix polaris, Wolf.

St. 129... ... 6 ♀ at 750–500 m.

Taken in the Antarctic by the 'Gauss'[1] and 'Terra Nova'.[2]

[1] Wolfenden (1911).

[2] Farran (1929).

Scolecithrix valida, Farran.

St. 138... ...	7	at	2000–1000 m.	St. WS 44 ...	2 ♀	at	750–500 m.
St. WS 26 ...	1	at	750–500 m.		1 ♀	at	1000–750 m.
	3 ♀	at	1000–750 m.	St. WS 69 ...	10(?)	at	1000–750 m.

Two specimens, female, were taken in the Antarctic by the 'Terra Nova'.[1]

Scolecithrix ovata, Farran. All the specimens of the genus *Scolecithrix* taken by us in the Antarctic Zone, were caught below a depth of 250 m. and usually deeper, in the intermediate layer, with the exception of two females of *S. ovata* taken at St. 17 at 250–100 m.

St. 17	2 ♀	at	250–100 m.	St. WS 22 ...	1 ♀	at	500–250 m.
St. 129... ...	2 ♀	at	750–500 m.	St. WS 36 ...	5 ♀	at	750–500 m.
	7 ♀	at	950–780 m.	St. WS 38 ...	1	at	750–500 m.
St. 137... ...	1 ♀	at	700–500 m.	St. WS 67 ...	2 ♀	at	1000–300 m.
St. 151... ...	2 ♀	at	750–500 m.				

This species was taken by the 'Terra Nova'[1] at five stations between 66° 30′ and 76° S in vertical hauls from 500 m. or more, and in one horizontal haul of only 60 m.

Scolecithrix emarginata, Farran.

St. WS 44 ...	13 ♀	at	750–500 m.	St. WS 63 ...	8 ♀	at	1000–750 m.
	7 ♀	at	1000–750 m.	St. WS 67 ...	2 ♀	at	1000–300 m.
St. WS 61 ...	4 ♀	at	1000–750 m.	St. WS 69 ...	1 ♀	at	1000–750 m.

This species has not been recorded in the Antarctic Zone before.

Scolecithrix spp.

St. 125... ...	1 ♂	at	750–500 m.	St. WS 22 ...	3 ♀	at	1000–750 m.
St. 129... ...	178 juv.	at	500–250 m.		1 ♀	at	1000–750 m.
	7 juv.	at	950–750 m.	St. WS 36 ...	1 ♂	at	750–500 m.
	2 ♂	at	950–780 m.		88 juv.	at	750–500 m.
St. 137... ...	1 ♂, 1 ♀	at	700–500 m.		12 juv.	at	750–500 m.
	59 juv.	at	700–500 m.	St. WS 44 ...	5 juv.	at	500–250 m.
St. 138... ...	1 ♂	at	1000–750 m.		3 ♀	at	1000–750 m.
	2 ♀	at	2000–1000 m.	St. WS 61 ...	50 juv.	at	1000–750 m.
St. 151... ...	62 juv.	at	750–500 m.	St. WS 63 ...	1 ♂	at	1000–750 m.
	75 juv.	at	1000–750 m.	St. WS 70 ...	2 ♀	at	250–100 m.
St. 161... ...	1	at	500–250 m.	St. WS 110 ...	4 ♀	at	1000–750 m.
	25	at	750–500 m.	St. WS 111 ...	1 ♀	at	750–500 m.
	3 ♀	at	1000–750 m.				
	24 juv.	at	1000–750 m.				

Scaphocalanus affinis, G. O. Sars.

St. 138... ...	1 ♀	at	2000–1000 m.	St. 151... ...	1 ♀	at	500–625 m.

It was taken by the 'Terra Nova'[1] in two vertical hauls from 1000 and 1750 m. at 66° 30′ and 76° S.

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[1] Farran (1929).

Scaphocalanus brevicornis (Sars).

St. WS 61 ...	1 ♀	at 1000–750 m.
St. WS 63 ...	4 juv.	at 1000–750 m.
St. WS 68 ...	1 juv.	at 750–500 m.
St. WS 68 ...	2 juv. ♀	at 1000–750 m.
St. WS 69 ...	2 juv.	at 1000–750 m.

It was taken by the 'Terra Nova'[1] at seven stations in the Antarctic (66° 30′ to 76° S.) in vertical nets hauled from depths of 400 to 1760 m.

Scaphocalanus echinatus (Farran). This species like the previous one is found typically in the intermediate layer, only rarely being taken above 250 m.

St. 17	1 ♀	at 250–100 m.
St. 125	2 ♀	at 250–100 m.
	2 ♀	at 750–500 m.
St. 129	2 ♀	at 250–100 m.
	50 ♀	at 750–500 m.
St. 137	1	at 500–250 m.
	3 ♀	at 700–500 m.
St. 138	6 ♀	at 2000–1000 m.
St. 151	1 ♀	at 750–500 m.
St. 161	1 ♀	at 500–250 m.
	1 ♀	at 750–500 m.
St. WS 22 ...	1 ♀	at 500–250 m.
	1 ♀	at 750–500 m.
	1 ♀	at 1000–0 m.
	3 ♀	at 1000–750 m.
St. WS 26 ...	12 ♀	at 250–100 m.
	1 ♀	at 500–250 m.
	31	at 750–500 m.
	1 ♀	at 1000–750 m.
St. WS 30 ...	6 ♀	at 750–500 m.
St. WS 36 ...	5 ♀	at 750–500 m.
St. WS 38 ...	1 ♀	at 500–250 m.
	5 ♀	at 1000–750 m.
St. WS 44 ...	1 ♀	at 500–250 m.
	5 ♀	at 750–500 m.
	1 ♀, 1 ♂	at 1000–750 m.
St. WS 51 ...	1 ♀(?)	at 200–100 m.
St. WS 61 ...	49, 2 ♀	at 500–250 m.
	1 ♀	at 750–500 m.
	2 ♀	at 1000–750 m.
St. WS 67 ...	1 ♀	at 500–250 m.
	1 ♀	at 750–500 m.
	12 ♀	at 1000–300 m.
St. WS 69 ...	6 ♀, 1 ♂	at 1000–750 m.
St. WS 70 ...	8 ♀	at 1000–750 m.
St. WS 110 ...	1 ♀	at 750–500 m.

A few specimens were taken in the Antarctic by the 'Terra Nova'.[1]

Scaphocalanus sp.

St. 125	1 ♂(?)	at 1000–750 m.
St. WS 36 ...	1 ♀	at 750–500 m.
St. WS 63 ...	1 ♂	at 1000–750 m.
St. WS 69 ...	1 ♂	at 1000–750 m.

Scolecithricella glacialis (Giesbr.). This species was confined in the Antarctic Zone to the intermediate layer, but appeared nearer the surface at Sts. 68 and 69 north of the Antarctic Convergence.

St. 125	1 ♂(?)	at 1000–750 m.
St. 138	17(?)	at 1000–750 m.
	1 ♀	at 2000–1000 m.
St. WS 63 ...	2 ♂	at 750–500 m.
St. WS 68 ...	1 ♀	at 50–0 m.
St. WS 68 ...	1 ♀,	at 100–50 m.
	4 juv.	at 100–50 m.
	1 ♀	at 250–100 m.
St. WS 69 ...	1 ♀	at 250–100 m.

It was taken in the Antarctic by the 'Gauss',[2] 'Terra Nova'[1] and 'Aurora'.[3]

Scolecithricella minor (Brady). This northern temperate Atlantic species has not been recorded in the Antarctic Zone before, yet it was widely distributed throughout our

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[1] Farran (1929).

[2] Wolfenden (1911).

[3] Brady (1918).

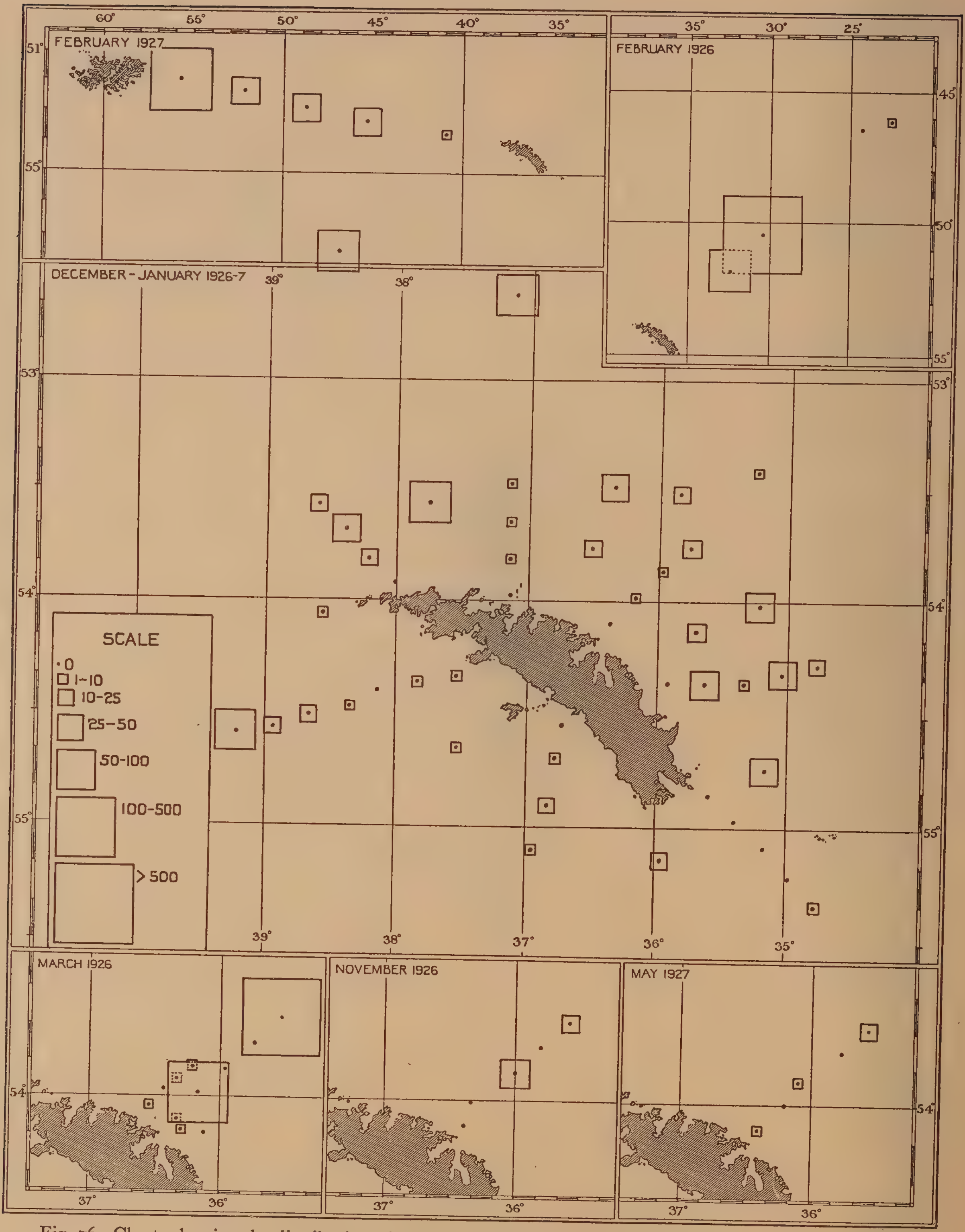
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
•0
□ 1-10
□ 10-25
□ 25-50
□ 50-100
□ 100-500
□ > 500
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 76. Charts showing the distribution of *Scolecithricella minor* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

area and at times occurred in large numbers. The complete record of its occurrence in this survey is given in Appendix II. It was very "patchy" in its distribution; for example, on the C line in March 1926, the average numbers, per 50 m. haul, with the N 70 V net at the five stations 10 miles apart, were 9, 324, 5, 0 and 487 respectively. Its general distribution is shown in Fig. 76; and its vertical distribution in Figs. 77, 78. It was most abundant between 250 and 100 m. but was occasionally taken between 1000 and 750 m. It showed indications of a vertical migration over a considerable range in depth; this is described on p. 237.

Racovitzanus antarcticus, Giesbr. Of general distribution but never abundant, and never occurring in the top 100 m.

St. 125 ...	... N 70 V	20 juv.	at	250–100 m.
		2 ♀	at	500–250 m.
		7 ♀	at	750–500 m.
St. 129 ...	... N 70 V	6 ♀	at	750–500 m.
		8 ♀	at	230–100 m.
St. 151 ...	... N 70 V	2 ♀	at	500–250 m.
		35 juv.	at	500–250 m.
St. WS 20	... N 70 V	23	at	500–250 m.
St. WS 21	... N 70 V	1	at	750–500 m.
St. WS 26	... N 70 V	12	at	250–100 m.
		39	at	500–250 m.
St. WS 29	... N 70 V	8 ♀, 2 ♂	at	250–100 m.
		1 ♀	at	500–250 m.
		3 ♀	at	600–500 m.
St. WS 30	... N 70 V	29	at	250–100 m.
		29	at	500–250 m.
St. WS 36	... N 70 V	4 ♀	at	750–500 m.
St. WS 37	... N 70 V	14	at	250–100 m.
St. WS 37	... N 70 V	20	at	310–250 m.
St. WS 39	... N 70 V	13	at	232–100 m.
St. WS 44	... N 70 V	15	at	500–250 m.
St. WS 50	... N 70 V	7	at	225–100 m.
St. WS 54	... N 70 V	44 ♀	at	500–250 m.
St. WS 61	... N 70 V	31 ♀, 30 ♂	at	250–100 m.
		146	at	500–250 m.
St. WS 63	... N 70 V	20	at	500–250 m.
St. WS 67	... N 70 V	41	at	500–250 m.
		2 juv.	at	1000–300 m.
St. WS 70	... N 70 V	49	at	500–250 m.
		118	at	750–500 m.
St. WS 110 ...	N 70 V	2 ♀	at	500–300 m.
		37 juv.	at	500–300 m.
St. WS 111 ...	N 70 V	17	at	500–250 m.
		7 ♀	at	750–500 m.
St. WS 112 ...	N 70 H	1	at	154 m.

This species is widely distributed in the Antarctic, being taken by the 'Belgica',[1] 'Gauss',[2] 'Scotia',[3] 'Terra Nova'[4] and 'Aurora'.[5]

CENTROPAGIDAE

Pleuromamma abdominalis (Lubbock). A single male specimen was taken in the cold surface layer at St. 36, 90–0 m. It was taken by the 'Terra Nova',[4] but not south of 60°.

Pleuromamma xiphias, Giesbr. Four female specimens were taken at St. 36, 50–0 m., in the cold surface layer. It has not been taken before in the Antarctic Zone.

Pleuromamma robusta (F. Dahl).

This species was of very general distribution but never abundant. It was taken at all depths from 1000 m. to the surface. A complete record of its occurrence is given in Appendix II. It was taken by the 'Terra Nova'[4] but not south of latitude 53° S.

Pleuromamma gracilis (Claus).

St. 139 ... ... 36 at 100–50 m.

Like *P. robusta* it was taken by the 'Terra Nova'[4] but not south of 53° S.

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[1] Giesbrecht (1902). [2] Wolfenden (1911). [3] Scott (1912). [4] Farran (1929). [5] Brady (1918).

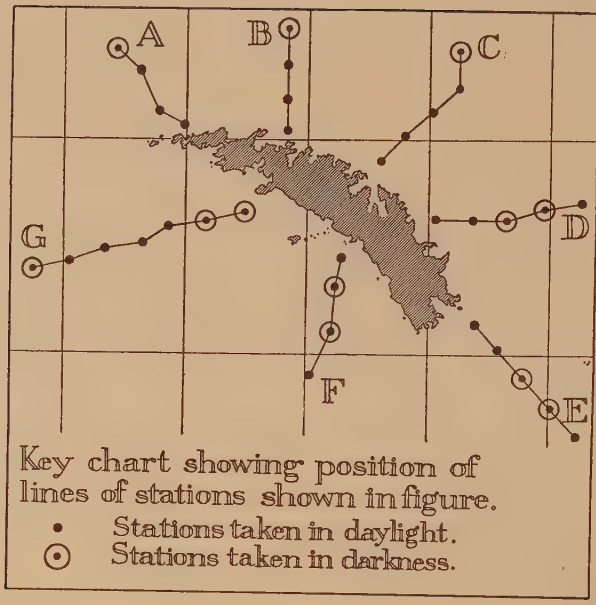
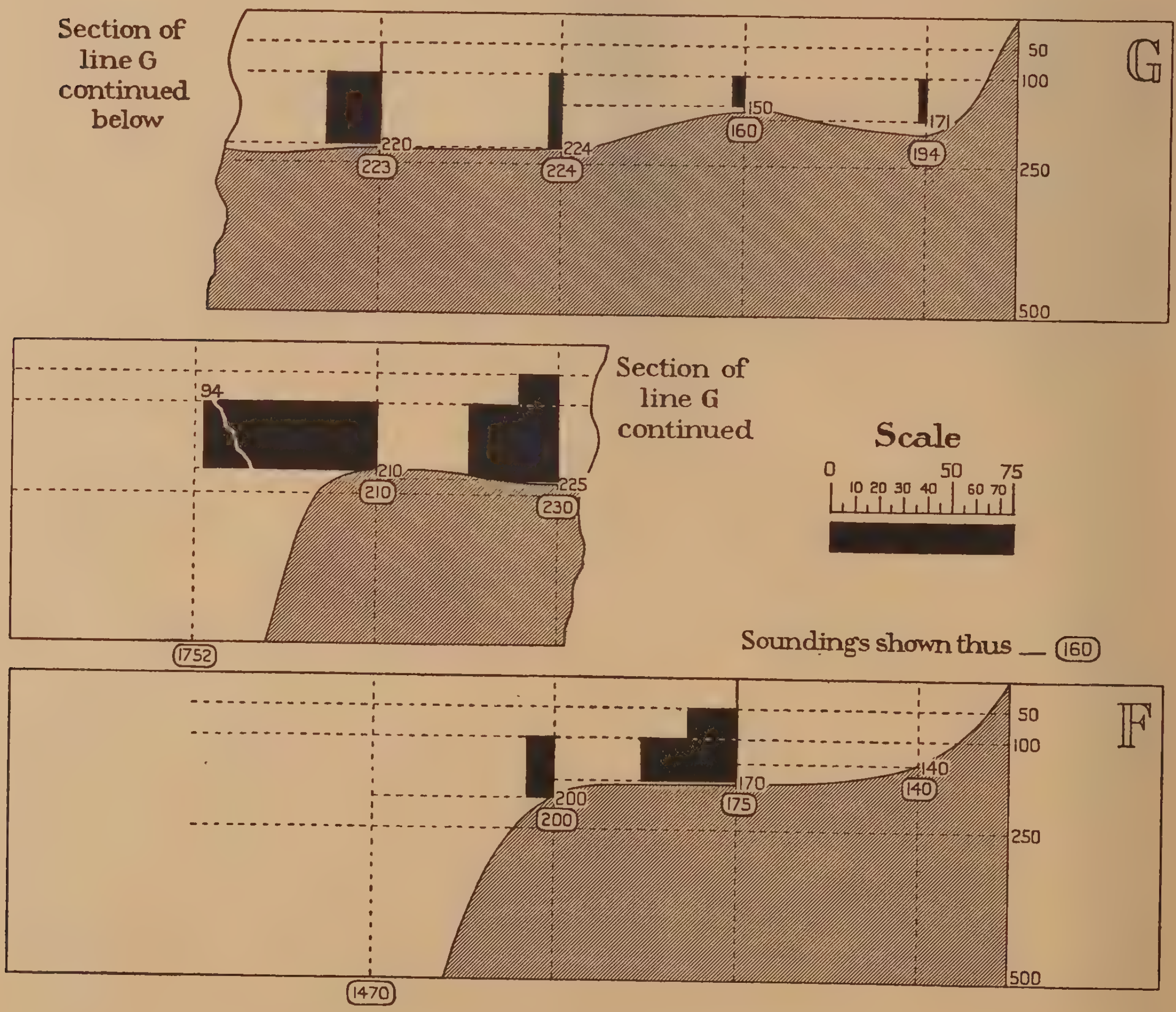

A
B
C
D
E
F
G
Key chart showing position of lines of stations shown in figure.
• Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 77. Showing the vertical distribution of **Scolecithricella minor** (Brady) down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



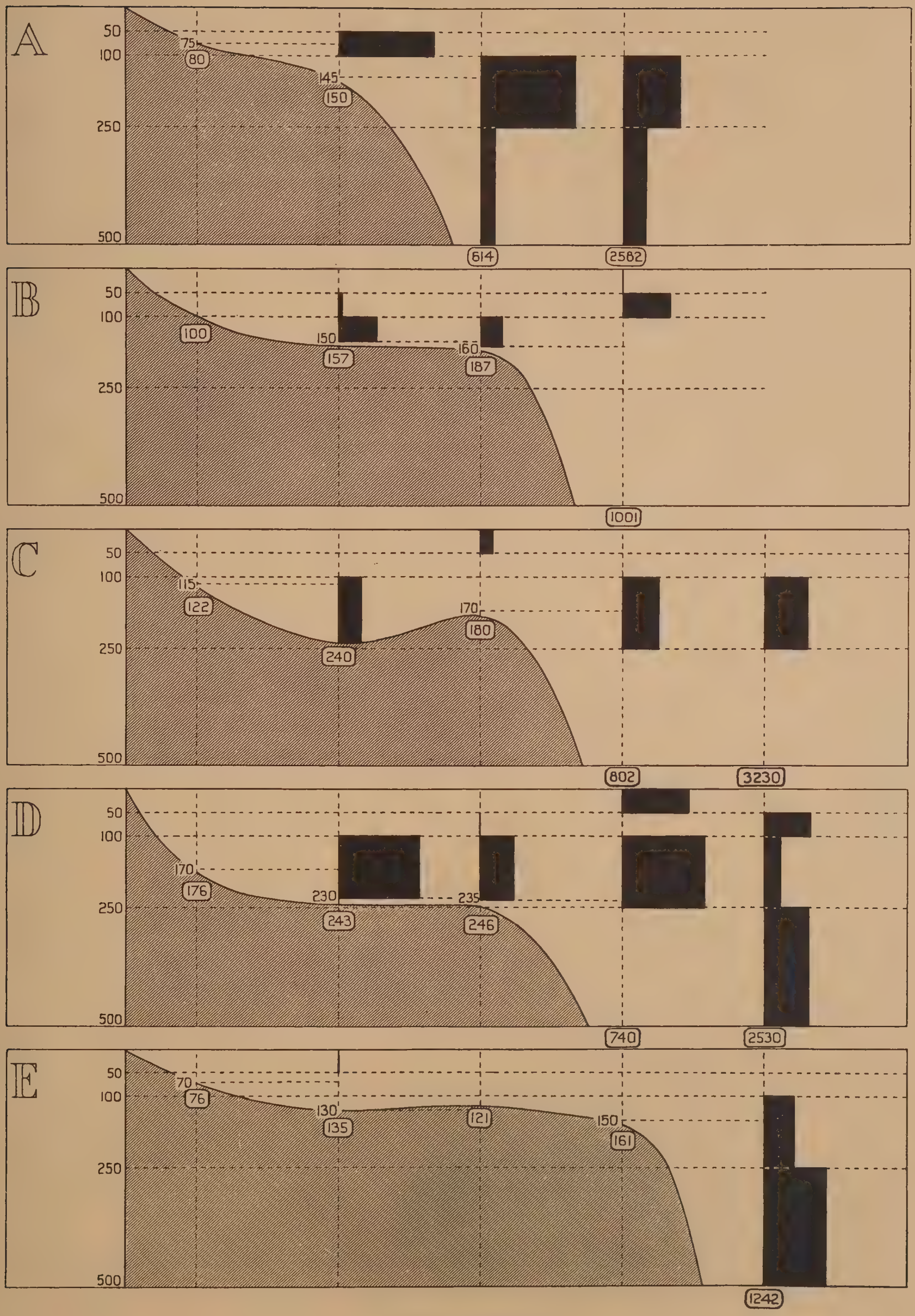


Fig. 77—*continued*

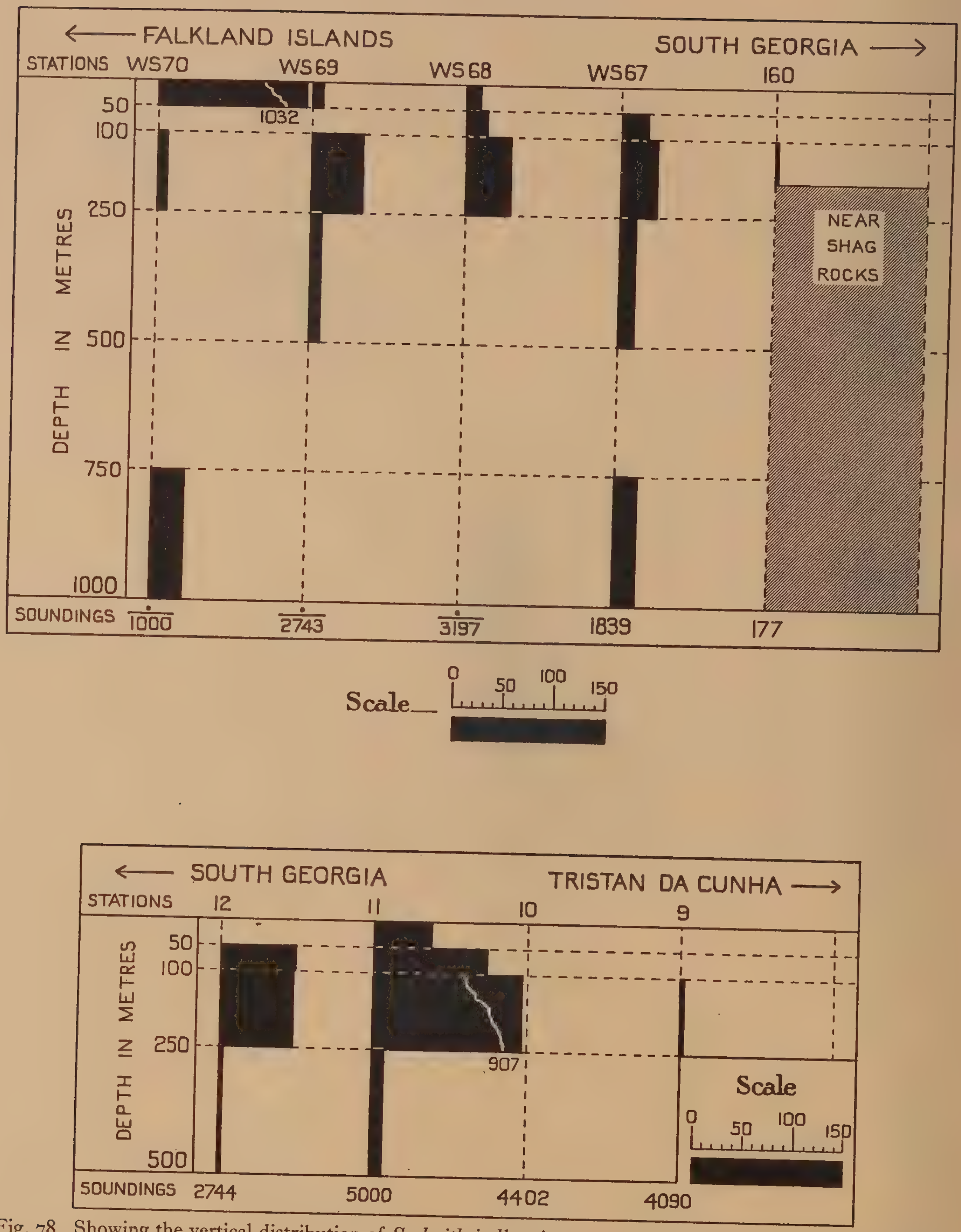


Fig. 78. Showing the vertical distribution of *Scolecithricella minor* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.

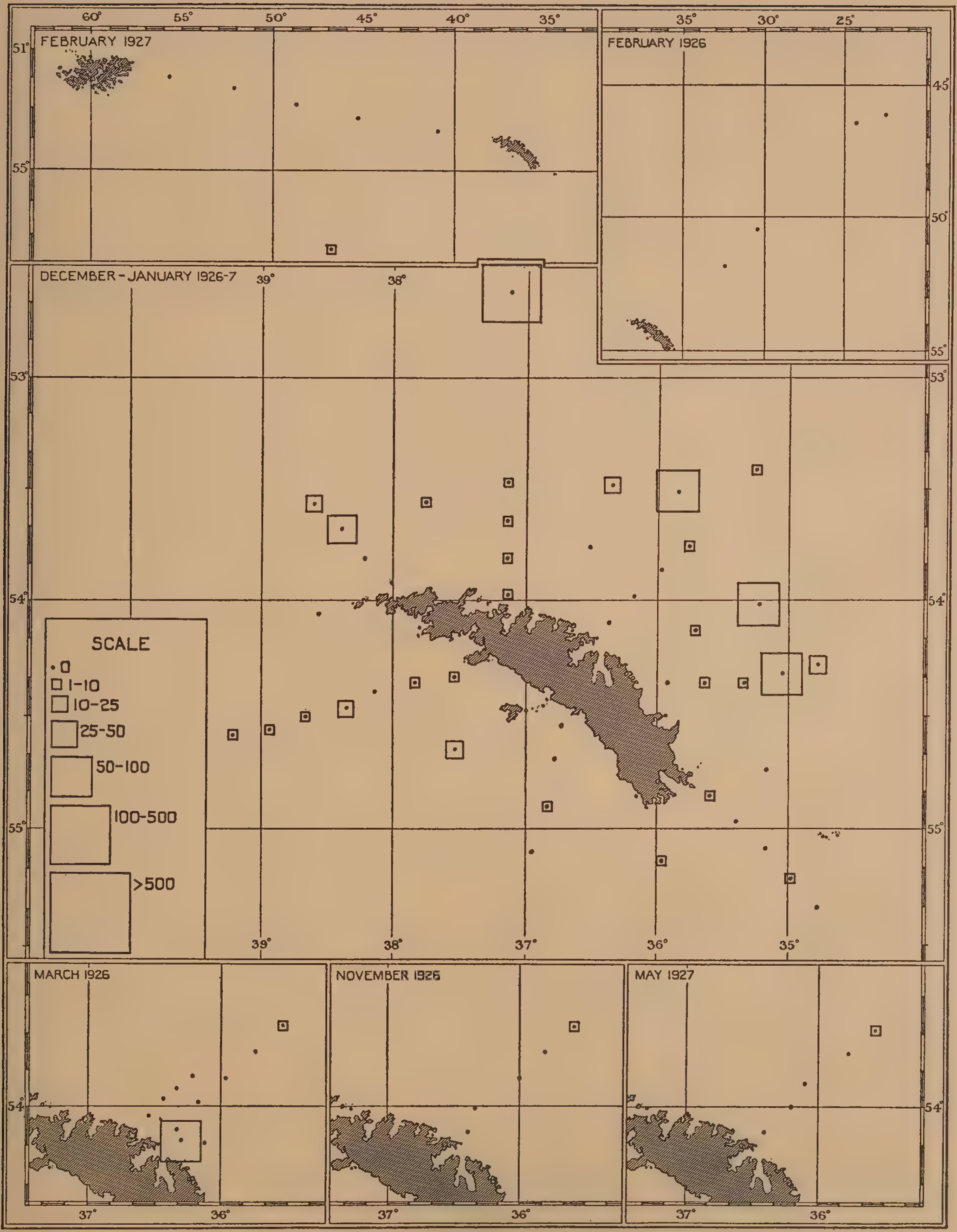

FEBRUARY 1927
FEBRUARY 1926
DECEMBER - JANUARY 1926-7
MARCH 1926
NOVEMBER 1926
MAY 1927
SCALE
• 0
1-10
10-25
25-50
50-100
100-500
>500
60°
55°
50°
45°
40°
35°
30°
25°
39°
38°
37°
36°
51°
53°
54°
55°
45°
50°

Fig. 79. Charts showing the distribution of *Metridia gerlachei* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

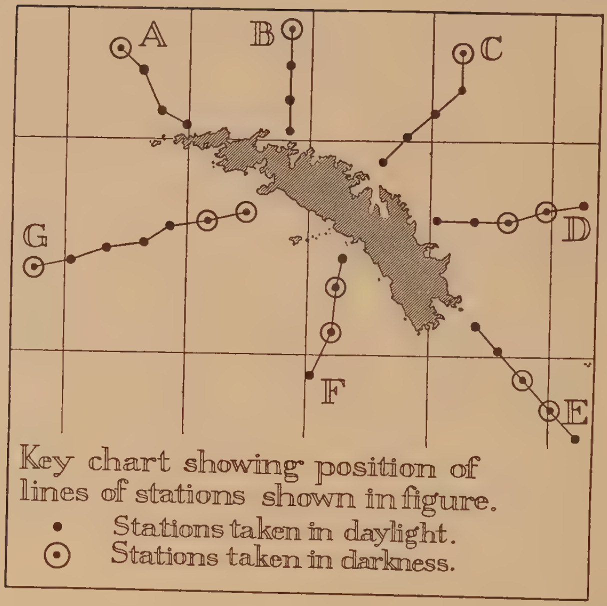
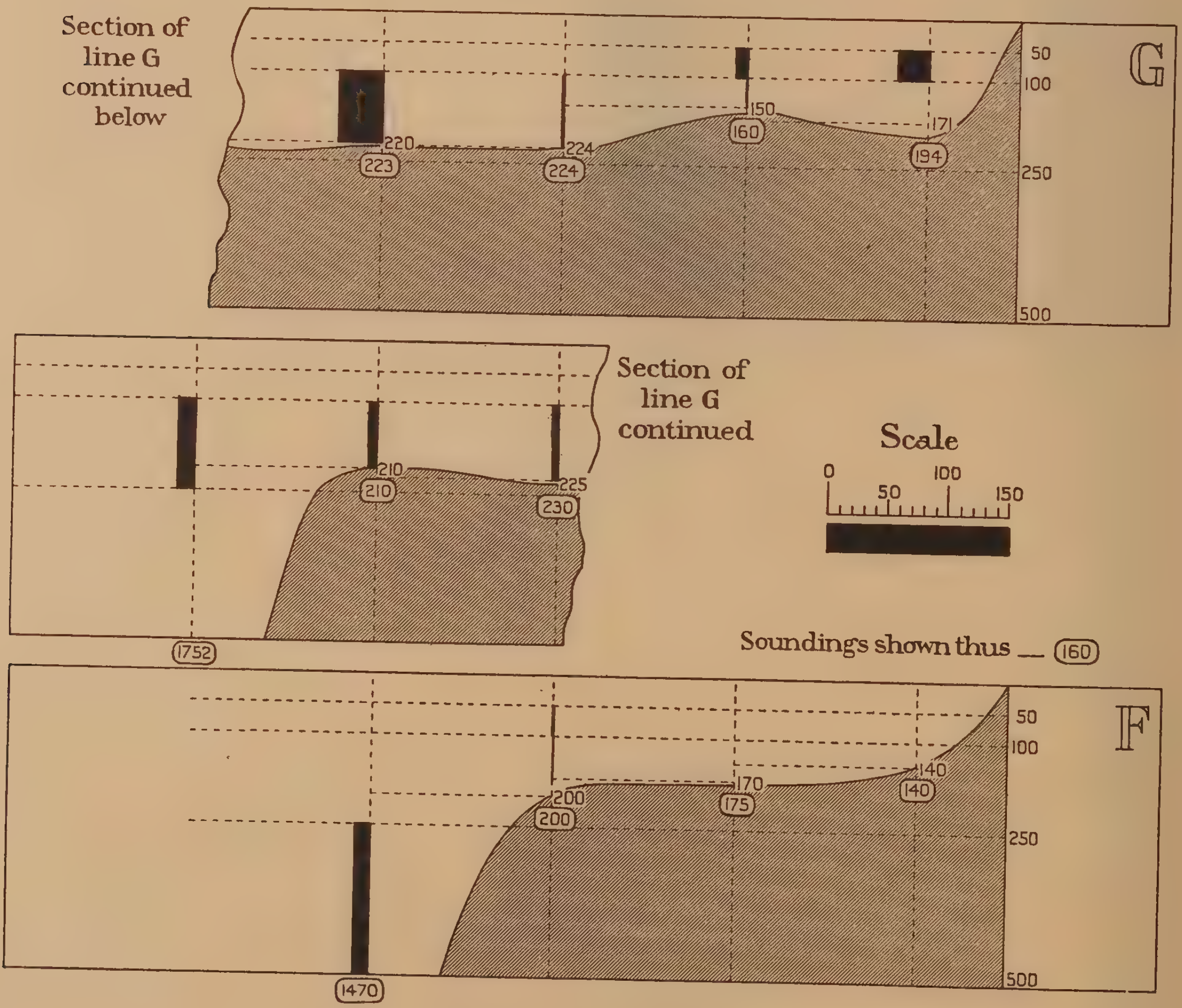

A
B
C
D
E
F
G
Key chart showing position of lines of stations shown in figure.
• Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 80. Showing the vertical distribution of **Metridia gerlachei**, Giesbr. down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



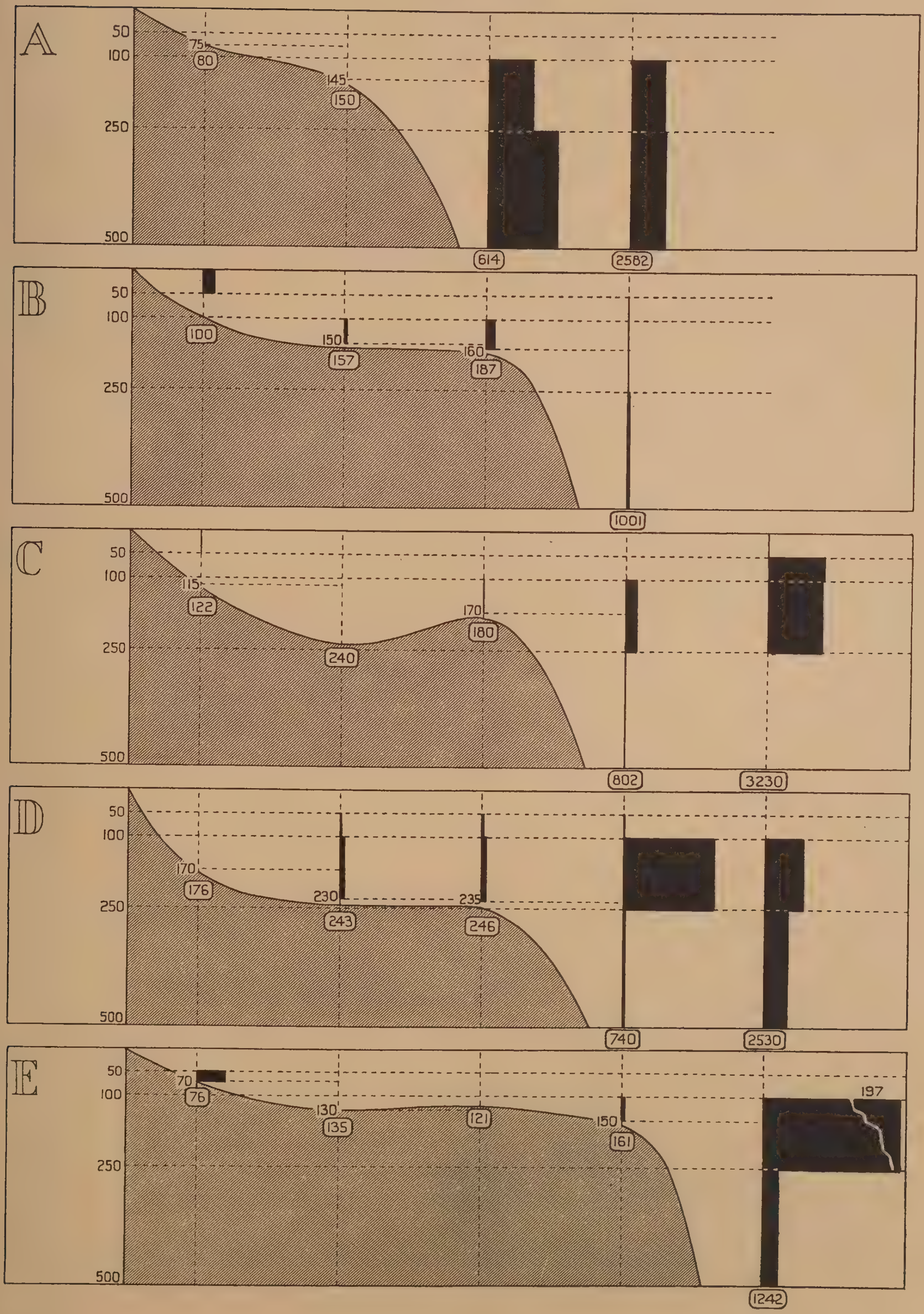


Fig. 80—*continued*

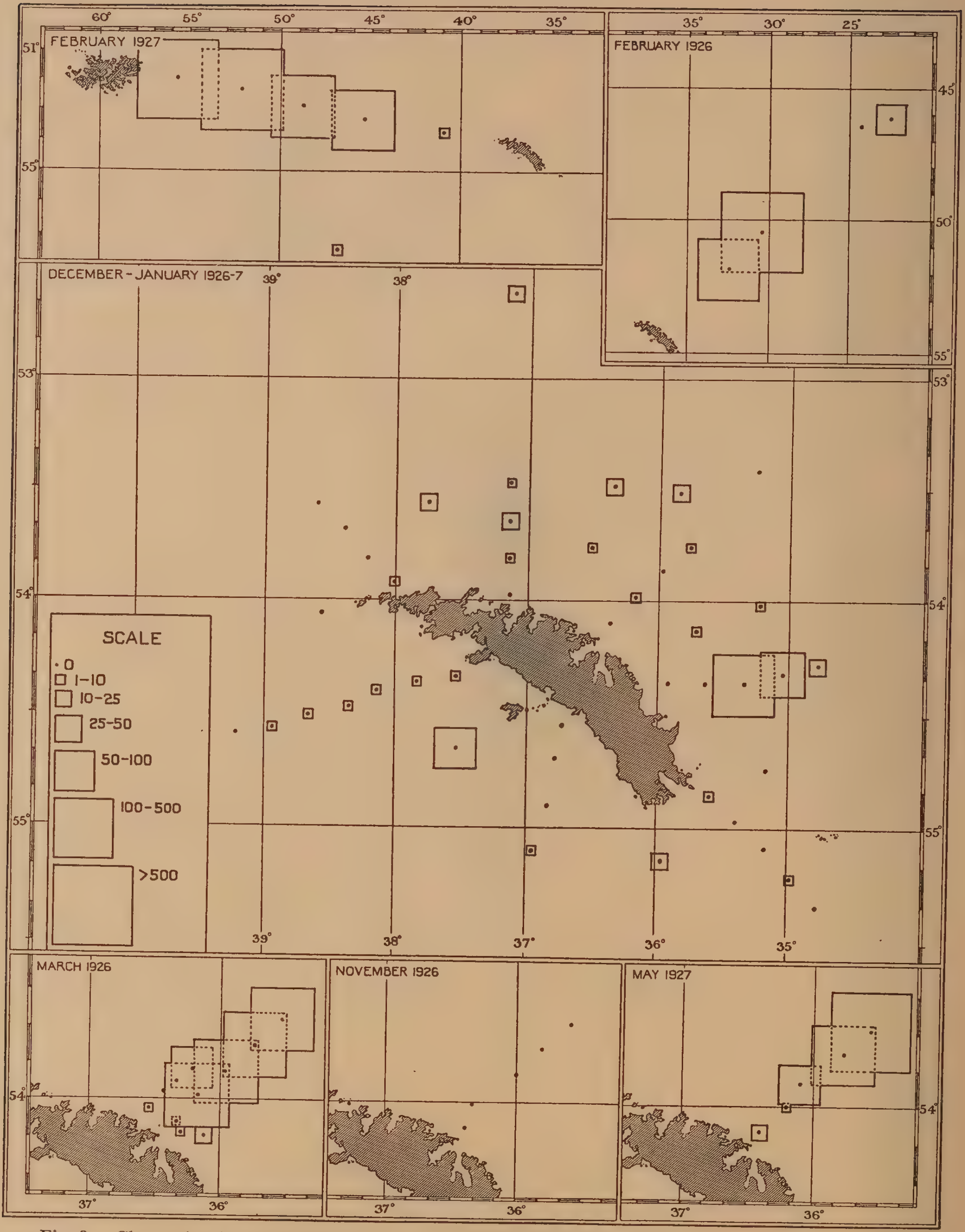

FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
DECEMBER-JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
· 0
1-10
10-25
25-50
50-100
100-500
>500
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 81. Charts showing the distribution of *Metridia lucens* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

Metridia brevicauda, Giesbr. Mr Andrew Scott records two forms of this species.

Form (*a*)

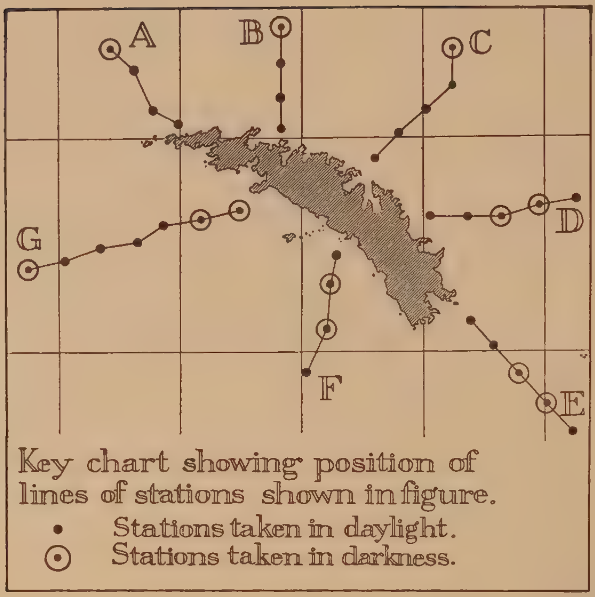
St. 125	N 70 V	87♀	at 1000–750 m.
St. 127	N 70 V	2	at 150–110 m.
St. 129	N 70 V	209♀	at 750–500 m.
St. 133	N 70 V	5	at 270–100 m.
St. 137	N 70 V	17♀	at 700–500 m.
		15♀	at 700–500 m.
St. 138	N 70 V	247♀	at 750–500 m.
		86♀	at 1000–750 m.
		5♀, 2♂	at 2000–1000 m.
		1 juv.	at 2000–1000 m.
St. 151	N 70 V	35	at 750–500 m.
		46	at 1000–750 m.
St. 161	N 70 V	26	at 750–500 m.
		33	at 1000–750 m.
St. WS 22 ...	N 70 V	133	at 500–250 m.
		65	at 750–500 m.
St. WS 26 ...	N 70 V	86	at 750–0 m.
		32	at 750–500 m.
		15	at 1000–750 m.
St. WS 29 ...	N 70 V	7♀	at 600–500 m.
St. WS 30 ...	N 70 V	22	at 500–330 m.
		14♀	at 750–500 m.
		1♀	at 1000–750 m.
St. WS 36 ...	N 70 V	51	at 750–500 m.
		6♀	at 1000–750 m.
St. WS 38 ...	N 70 V	192	at 500–250 m.
St. WS 38 ...	N 70 V	186	at 750–500 m.
		137	at 1000–750 m.
St. WS 44 ...	N 70 V	22♀	at 750–500 m.
		5♂	at 750–500 m.
		17 juv.	at 750–500 m.
		15♀	at 1000–750 m.
		2♂	at 1000–750 m.
		14 juv.	at 1000–750 m.
	N 100 H	1♀	at 0–5 m.
St. WS 61 ...	N 70 V	8♀	at 750–500 m.
		52	at 1000–750 m.
St. WS 63 ...	N 70 V	218	at 750–500 m.
		129	at 1000–750 m.
St. WS 67 ...	N 70 V	3♀	at 750–500 m.
St. WS 68 ...	N 70 V	1♀	at 250–100 m.
		12♀	at 1000–750 m.
		22♂	at 1000–750 m.
St. WS 69 ...	N 70 V	16♀	at 1000–750 m.
St. WS 70 ...	N 70 V	1032	at 50–0 m.
		44	at 100–50 m.
		5♀	at 1000–750 m.
St. WS 110 ...	N 70 V	3♀	at 750–500 m.
		94	at 1000–750 m.
St. WS 111 ...	N 70 V	15♀	at 750–500 m.
		25♀	at 1000–750 m.

Form (*b*)

St. 129	81♀	at 950–780 m.
St. 138	37♂	at 2000–1000 m.
	74♀	at 2000–1000 m.
St. WS 30 ...	72♀	at 750–500 m.
St. WS 61 ...	62	at 750–500 m.
St. WS 69 ...	115	at 1000–750 m.

It is seen that the species is usually confined to the intermediate layer, but a single specimen was taken at the surface at St. WS 44 in the Antarctic Zone, and very many were taken at the surface at St. WS 70 in the sub-Antarctic Zone. It has not been recorded before in the Antarctic Zone.

Metridia gerlachei, Giesbr. This species has been shown by previous expeditions to be a typically Antarctic species. Farran (1929), in his report on the Terra Nova collections, writes that it "was found mainly from the Antarctic Circle southwards....The most northerly point at which live specimens were taken was 61° 18′ S, but a few dead specimens were found as far north as 52° 41′ S". In our area we see that it was taken at the majority of stations round South Georgia and at St. 161 to the south-west, but as one would expect it was absent from stations to the north of the line of Antarctic Convergence. Its distribution is shown in Fig. 79 and its vertical distribution in Fig. 80. It rarely occurred in the top 50 m., it being most abundant between 500 and 100 m., but extending down to below 1000 m. As one would expect, it was not usually met with


A
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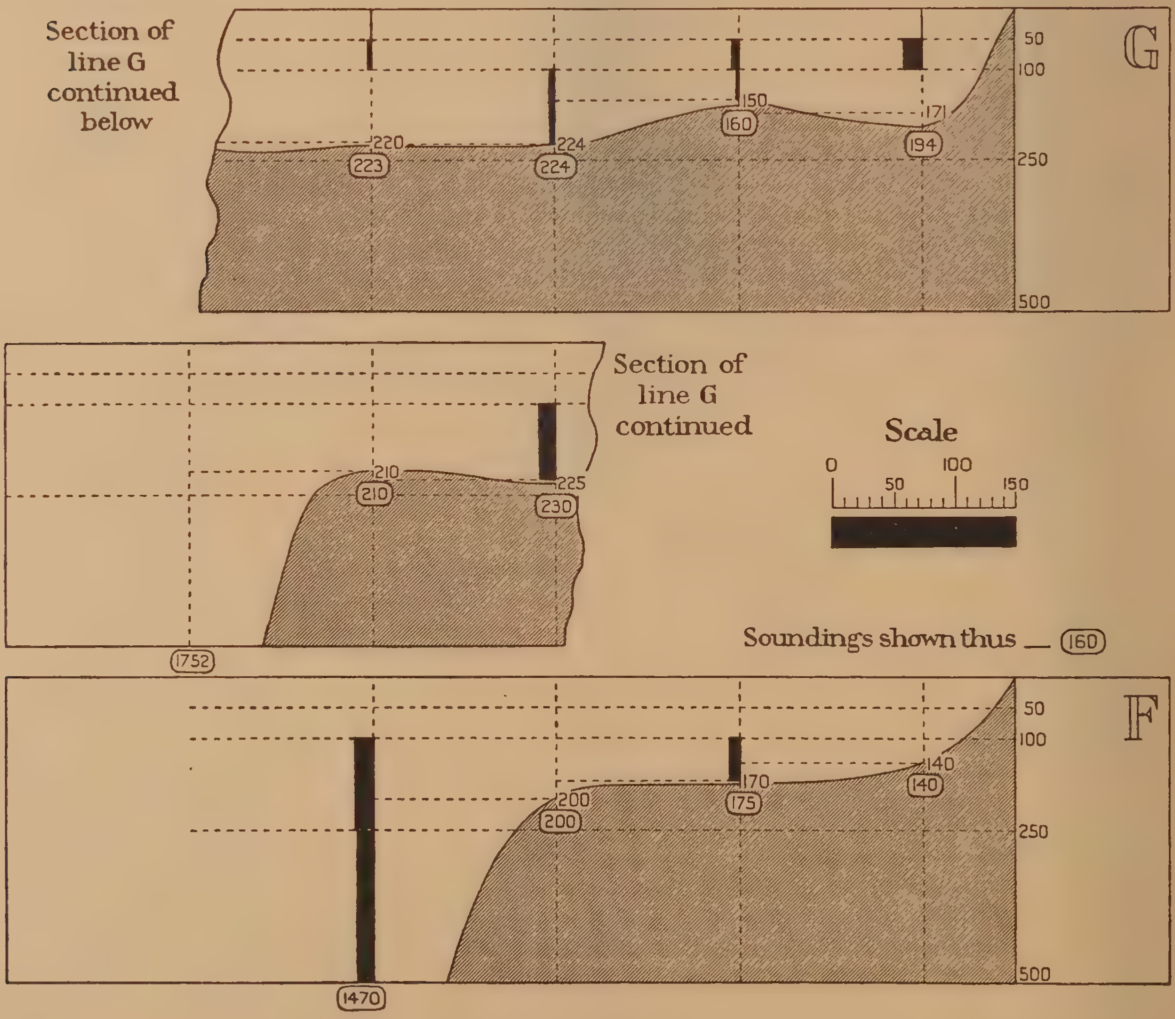
Key chart showing position of lines of stations shown in figure.
● Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 82. Showing the vertical distribution of **Metridia lucens**, Boeck down to 500 m. on lines of stations in the South Georgia December–January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



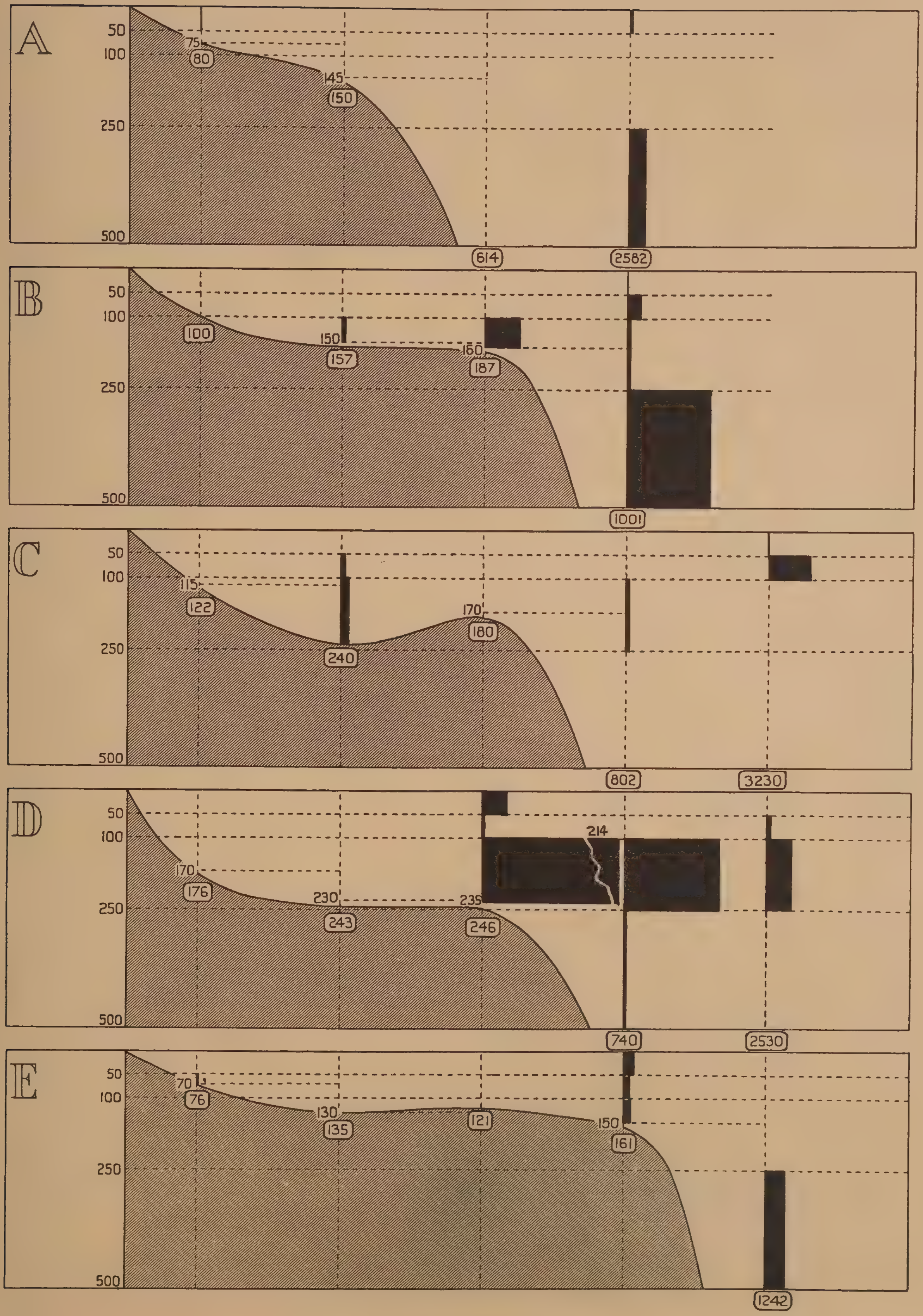


Fig. 82—*continued*

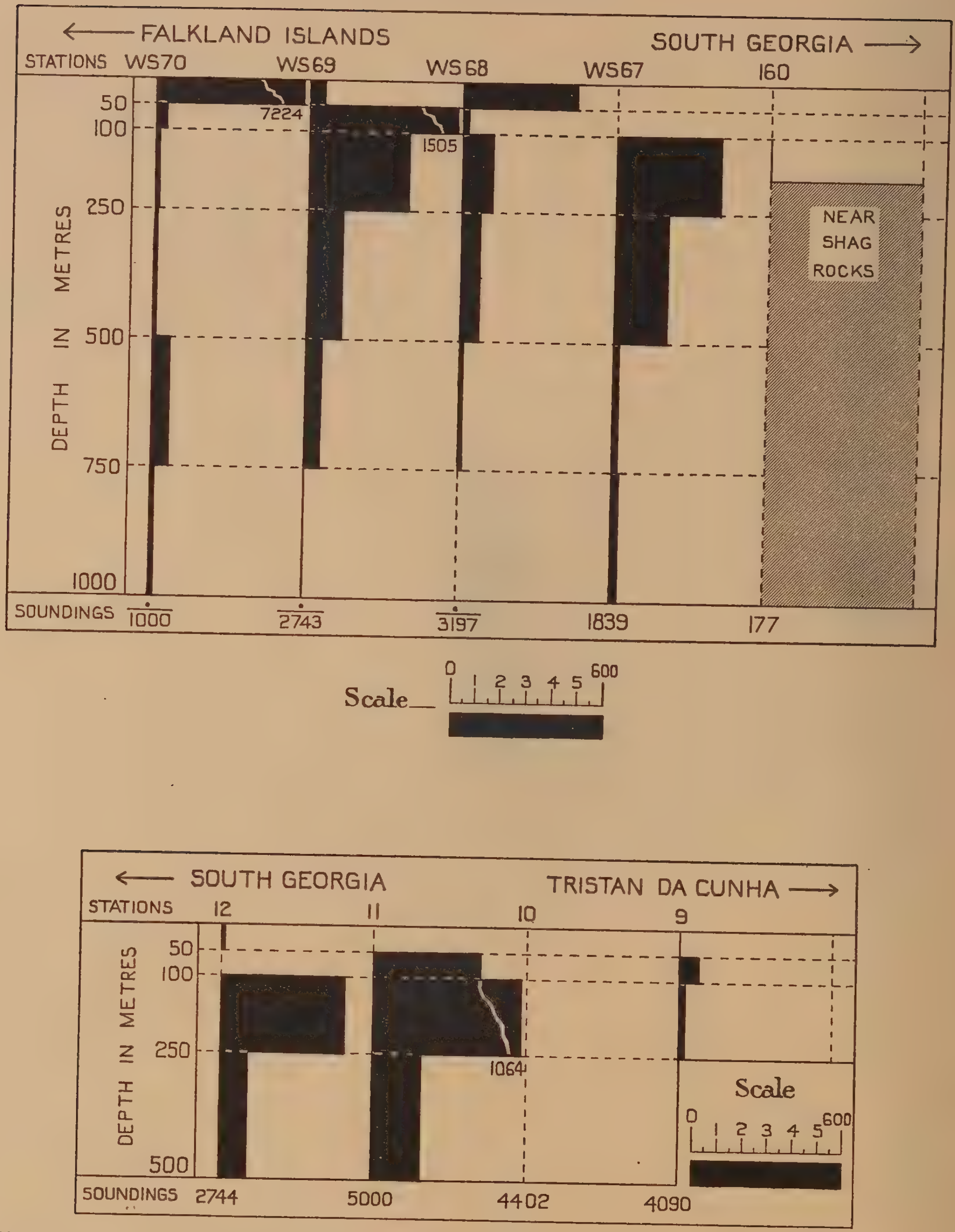


Fig. 83. Showing the vertical distribution of *Metridia lucens* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.

inside the edge of the continental shelf. It gave marked indications of a vertical migration over a considerable range of depth; this is described on p. 236. The complete record of its occurrence is given in Appendix II.

It has been taken by the Belgica,[1] Scotia,[2] Gauss,[3] Terra Nova,[4] Aurora[5] and Vikingen[6] Expeditions.

Metridia lucens, Boeck. The complete record of its occurrence is shown in Appendix II. It was widely distributed throughout the area, but rarely abundant, and the maximum number per 50 m. haul with the N 70 V net, 7224, was taken in the top 50 m. at St. 70 towards the Falkland Islands out of the Antarctic Zone across the line of Antarctic Convergence. Its distribution is shown in Fig. 81. It was more abundant at the oceanic stations approaching South Georgia from the north-east in February 1926 and between South Georgia and the Falklands in February 1927 than it was in the waters immediately surrounding South Georgia in the December–January survey of 1926–7; but this may partly be due to an increase with the advancing season, for in March 1926 it was more abundant off the north-east coast of South Georgia than it was during the December–January survey.

Its vertical distribution is shown in Figs. 82 and 83. There were indications of a vertical migration upwards at night; this is further discussed on p. 236.

It was taken by the 'Terra Nova'[4] as far south as 71° 49′ S, but only in small numbers south of latitude 60° S. It is no doubt widely distributed in the Southern Ocean; Stebbing (1910) describes it as abundant south and west of Cape Colony.

Metridia princeps, Giesbr. This species was probably confined to the intermediate layer, although it may have occurred in the cold deep-water layer at St. 138.

St. 138... ...	1 ♂, 1 ♀	at 2000–1000 m.	St. WS 68 ...	1 ♀	at 1000–750 m.
St. WS 22 ...	1 ♂	at 1000–750 m.	St. WS 70 ...	1 ♀	at 1000–750 m.
St. WS 26 ...	1 ♂ juv.	at 750–0 m.			

It was taken by the 'Gauss'[3] in the region of Heard Island, and by the 'Terra Nova'[4] within the Antarctic Circle. *M. curticauda*, Giesbr., which was taken in numbers by the 'Terra Nova'[4] from depths of 600 m. and more between 66° 30′ and 76° S, was not recorded in our collections.

Lucicutia magna, Wolf.

St. WS 22 ...	1	at 750–500 m.	St. WS 69 ...	1	at 1000–750 m.
St. WS 38 ...	1 ♀	at 1000–750 m.			

This species was taken by the 'Terra Nova'[4] in two vertical hauls from 1000 and 600 m. in the Antarctic.

Lucicutia maxima, Steuer.

St. 129... ... 1 ♂, 1 ♀ at 950–780 m.

Not previously recorded from the Antarctic Zone.

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[1] Giesbrecht (1902).
[2] Scott (1912).
[3] Wolfenden (1911).
[4] Farran (1929).
[5] Brady (1918).
[6] Ottestad (1932).

Lucicutia frigida, Wolf. This species was probably confined to the intermediate layer, although it may have occurred in the cold deep water below 1500 m. at St. 138.

St. 129	96 juv.	at 950–780 m.
St. 138	131 juv.	at 1000–750 m.
	36 ♀	at 2000–1000 m.
	154 juv.	at 2000–1000 m.
St. WS 26 ...	50 juv.	at 1000–750 m.
St. WS 30 ...	8 juv.	at 1000–750 m.
St. WS 36 ...	32 juv.	at 1000–750 m.
St. WS 63 ...	66 juv.	at 750–500 m.
	68 juv.	at 1000–750 m.
St. WS 67 ...	1 juv.	at 750–500 m.
	1 ♀	at 1000–750 m.

Recorded in the Antarctic by the 'Gauss'[1] in hauls from 1200 to 3000 m.

Disseta palumboi, Giesbr.

St. WS 36 ...	1 ♀	at 750–500 m.
St. WS 44 ...	2 ♂	at 1000–750 m.

Not previously recorded from the Antarctic Zone.

Heterorhabdus austrinus, Giesbr. Of general distribution but never abundant. It occurred most frequently between 750 and 250 m., but occasionally was taken in the top 50 m., and on one occasion was taken below 1000 m.

St. 9	N 70 V	31 juv.	at 100–50 m.
St. 11	N 70 V	33 ♂	at 500–250 m.
		33 ♀	at 500–250 m.
St. 12	N 70 V	18 ♀	at 500–250 m.
St. 17	N 70 V	20 ♂	at 500–250 m.
		41 ♀	at 500–250 m.
		82 juv.	at 500–250 m.
St. 38	N 100 H	3	at 155 m.
St. 125	N 70 V	3	at 250–100 m.
		3	at 500–250 m.
		11 juv.	at 500–250 m.
		26 juv.	at 750–500 m.
		20 juv.	at 1000–750 m.
St. 127	N 70 V	1 ♀	at 150–110 m.
St. 129	N 70 V	71 juv.	at 500–250 m.
		3 ♂	at 750–500 m.
		11 ♀	at 750–500 m.
		3 juv.	at 750–500 m.
		6 ♀	at 950–780 m.
St. 133	N 70 V	2	at 500–250 m.
		1 ♀	at 750–500 m.
St. 135	N 70 V	2	at 230–100 m.
St. 137	N 70 V	19 juv.	at 250–100 m.
		1 ♂	at 500–250 m.
		1 juv.	at 500–250 m.
		4 ♀	at 700–500 m.
		10	at 700–500 m.
St. 138	N 70 V	69 juv.	at 500–250 m.
		1 ♂	at 1000–750 m.
		18 ♀	at 1000–750 m.
		26 ♀	at 2000–1000 m.
St. 139	N 70 V	2 ♀	at 250–150 m.
St. 150	N 100 H	1	at 0–5 m.
St. 151	N 70 V	2 ♀	at 500–250 m.
		10 ♀	at 750–500 m.
		6 ♀	at 1000–750 m.
	N 100 H	14 ♂	at 500–625 m.
		5 ♀	at 500–625 m.
St. 161	N 70 V	21	at 500–250 m.
		48	at 750–500 m.
		4	at 1000–750 m.
St. WS 22 ...	N 70 V	2 ♀	at 750–500 m
		1 + 2 juv.	at 1000–0 m.
		3 ♂	at 1000–750 m.
		2 ♀	at 1000–750 m.
St. WS 26 ...	N 70 V	1 ♀	at 250–100 m.
		2 ♀	at 500–250 m.
		2 ♀	at 750–0 m.
		8 ♂	at 1000–750 m.
	N 70 H	1	at 140 m.
St. WS 27 ...	N 70 V	1 ♂	at 50–0 m.
St. WS 29 ...	N 70 V	55	at 500–250 m.
		2 ♂	at 600–500 m.
St. WS 30 ...	N 70 V	48	at 500–250 m.
		10 juv.	at 750–500 m.
	N 100 H	1 ♀	at 134 m.
St. WS 36 ...	N 70 V	42	at 500–250 m.
		13	at 750–500 m.
St. WS 38 ...	N 70 V	9	at 250–100 m.
		3 ♀	at 500–250 m.
		2 ♂	at 500–250 m.
		6	at 750–500 m.

[1] Wolfenden (1911).

St. WS 44 ...	N 70 V	5	at 500–250 m.
		1♀, 2♂	at 750–500 m.
		1♀, 2♂	at 1000–750 m.
St. WS 45 ...	N 70 V	1♀	at 50–0 m.
St. WS 61 ...	N 70 V	1♀	at 50–0 m.
		4	at 500–250 m.
		2♀, 2♂	at 750–500 m.
St. WS 63 ...	N 70 V	4♀	at 1000–750 m.
		4 juv.	at 1000–750 m.
St. WS 67 ...	N 70 V	1 juv.	at 250–100 m.
		1♀, 2♂	at 750–500 m.
		8♀	at 1000–750 m.
		54	at 1000–300 m.
St. WS 68 ...	N 70 V	22	at 250–100 m.
		6	at 750–500 m.
		2♀	at 1000–750 m.
		1 juv.	at 1000–750 m.
St. WS 69 ...	N 70 V	34	at 750–500 m.
		1 juv.	at 1000–750 m.
St. WS 70 ...	N 70 V	344 juv.	at 50–0 m.
		39 juv.	at 750–500 m.
		2♂	at 1000–750 m.
St. WS 110 ...	N 70 V	1 juv.	at 500–300 m.
		51	at 1000–750 m.
	N 70 H	1	at 0–5 m.
		3	at 62 m.
	N 100 H	1♀	at 102–0 m.
St. WS 111 ...	N 70 V	1♂, 2♀	at 500–250 m.
		12♀	at 750–500 m.
		4♀	at 1000–750 m.
	N 70 H	1♀, 2♂	at 84 m.
St. WS 112 ...	N 70 V	1♀	at 150–100 m.

It was taken in the Antarctic by the 'Scotia',[1] 'Belgica',[2] 'Terra Nova'[3] and 'Aurora'.[4]

Heterorhabdus compactus, G. O. Sars. This species was confined to the intermediate layer.

St. 129	2♀	at 500–250 m.
St. 137	9♀	at 700–500 m.
St. 161	10	at 750–500 m.
	20 juv.	at 1000–750 m.
St. WS 26 ...	7	at 750–500 m.
St. WS 29 ...	3	at 600–500 m.
St. WS 36 ...	4♂	at 750–500 m.
St. WS 38 ...	7	at 750–500 m.
	1♂	at 1000–750 m.
St. WS 44 ...	3	at 500–250 m.
St. WS 44 ...	6♀, 2♂	at 750–500 m.
	1♀, 1♂	at 1000–750 m.
St. WS 61 ...	1♀, 1♂	at 1000–750 m.
St. WS 63 ...	3♀	at 750–500 m.
St. WS 67 ...	1♂	at 750–500 m.
	2♀, 1♂	at 1000–300 m.
St. WS 69 ...	1♂	at 1000–750 m.
St. WS 70 ...	1♀	at 250–100 m.
	3♂	at 750–500 m.

It was taken in the Antarctic by the 'Terra Nova'[3] in two vertical hauls from 1750 and 1000 m. (latitude 66° 30′ to 76° S).

Heterorhabdus sp.

St. WS 22 ...	1♀	at 750–500 m.
	3♀, 1♂	at 1000–750 m.
St. WS 63 ...	1♀	at 1000–750 m.

Heterorhabdus spp. juv.

St. 126	24	at 50–0 m.
St. 129	66	at 950–780 m.
St. 138	31	at 2000–1000 m.
St. 151	28	at 500–250 m.
	4	at 750–500 m.
	10	at 1000–750 m.
St. WS 22 ...	32	at 500–250 m.
	15	at 750–500 m.
	18	at 1000–750 m.
St. WS 26 ...	12	at 250–100 m.
	19	at 500–250 m.
St. WS 29 ...	25	at 250–100 m.
	1	at 500–250 m.
	3	at 600–500 m.
St. WS 30 ...	32	at 500–330 m.
St. WS 30 ...	6	at 750–500 m.
	1	at 1000–750 m.

[1] Scott (1912).

[2] Giesbrecht (1902).

[3] Farran (1929).

[4] Brady (1918).

St. WS 38 ...	96	at	500–250 m.
	31	at	750–500 m.
	13	at	1000–750 m.
St. WS 44 ...	12	at	500–250 m.
	17	at	750–500 m.
	24	at	1000–750 m.
St. WS 54 ...	103	at	500–250 m.
St. WS 63 ...	42	at	500–250 m.
St. WS 68 ...	7	at	500–250 m.
	10	at	1000–750 m.
St. WS 69 ...	5	at	1000–750 m.
St. WS 70 ...	2	at	500–250 m.

Heterostylites,? *major* (Dahl). A single female specimen was taken from 1000–750 m. at St. 70 north of the Antarctic Convergence. The 'Terra Nova'[1] took two specimens in a vertical haul from 1750 m. south of latitude 66° 30′.

Haloptilus fons, Farran.

St. 151 ... ... 1 ♀, 1 juv. at 500–625 m.

St. WS 29 ... 1 ♀ at 250–100 m.

This specimen has not before been taken in the Antarctic Zone.

Haloptilus ocellatus, Wolf.

St. WS 26 ... 1 ♀ at 750–0 m.

It was taken in the Antarctic by the 'Gauss',[2] 'Terra Nova'[1] and 'Aurora'.[3]

Haloptilus oxycephalus, Giesbr. Of general distribution, but never abundant.

St. 17	N 70 V	2 ♀	at	500–250 m.
St. 124	N 100 H	4	at	180–90 m.
St. 125	N 70 V	7	at	250–100 m.
		2 ♂	at	250–100 m.
St. 129	N 70 V	1 ♀	at	750–500 m.
St. 131	N 70 V	8	at	230–100 m.
St. 132	N 70 V	7	at	170–125 m.
		6	at	170–0 m.
St. 133	N 70 V	5	at	270–100 m.
St. 136	N 70 V	6 ♀	at	235–100 m.
	N 70 H	2	at	96 m.
St. 137	N 70 V	5 ♀	at	250–100 m.
	N 70 H	1	at	120 m.
St. 138	N 70 V	16 ♀	at	250–100 m.
	N 70 V	6 ♀	at	2000–1000 m.
	N 100 H	1	at	155 m.
St. 139	N 70 V	6 ♀	at	250–100 m.
St. 151	N 70 V	10	at	500–250 m.
		1	at	750–500 m.
	N 100 H	1	at	500–625 m.
St. 160	N 70 V	1	at	180–100 m.
St. 161	N 70 V	2	at	250–100 m.
St. WS 18 ...	N 70 H	5 juv.	at	128 m.
St. WS 20 ...	N 70 V	1	at	500–250 m.
	N 70 H	1	at	164 m.
St. WS 21 ...	N 100 H	1	at	191 m.
St. WS 22 ...	N 70 V	1	at	1000–0 m.
	N 70 H	1 ♀	at	165 m.
	N 100 H	1	at	185 m.
St. WS 26 ...	N 70 V	5	at	250–100 m.
St. WS 26 ...	N 70 V	1	at	500–250 m.
		1	at	750–0 m.
		43 ♂	at	750–0 m.
St. WS 28 ...	N 70 H	2	at	68 m.
St. WS 29 ...	N 70 V	3	at	250–100 m.
		18	at	500–250 m.
St. WS 30 ...	N 70 V	29	at	250–100 m.
	N 100 H	1	at	134 m.
St. WS 36 ...	N 70 V	1	at	250–100 m.
		1	at	500–250 m.
		1 ♂	at	500–250 m.
St. WS 37 ...	N 70 V	14 ♂	at	250–100 m.
St. WS 38 ...	N 70 V	10	at	250–100 m.
		1	at	750–500 m.
St. WS 39 ...	N 70 V	4	at	232–100 m.
		1 ♂	at	232–100 m.
St. WS 43 ...	N 100 H	1 ♀	at	141 m.
St. WS 44 ...	N 70 V	1	at	500–250 m.
		7 ♂	at	500–250 m.
St. WS 47 ...	N 70 H	2	at	39 m.
St. WS 49 ...	N 70 V	1	at	225–100 m.
St. WS 51 ...	N 70 V	2 ♀	at	200–100 m.
St. WS 52 ...	N 70 V	5	at	180–100 m.
St. WS 54 ...	N 70 V	4	at	500–250 m.
St. WS 63 ...	N 70 V	3	at	500–250 m.
St. WS 67 ...	N 70 V	1	at	250–100 m.
		1 ♀	at	500–250 m.
		2 ♀	at	1000–300 m.
		1 juv.	at	1000–300 m.
St. WS 68 ...	N 70 V	1	at	500–250 m.

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[1] Farran (1929).

[2] Wolfenden (1911).

[3] Brady (1918).

St. WS 110 ... N 70 V 4 ♀ at 250–100 m.
St. WS 112 ... N 70 H 3 at 154 m.
St. WS 113 ... N 100 H 1 ♀ at 110 m.

It was taken by the 'Terra Nova'[1] at a number of stations between latitude 50° and 78° S.

Haloptilus spp. juv.

St. WS 20 ... 1 at 250–100 m.
St. WS 26 ... 2 at 1000–750 m.
St. WS 29 ... 1 at 250–100 m.

Augaptilus megalurus, Giesbr.

St. WS 44 ... 1 juv. at 500–250 m.
St. WS 68 ... 1 ♂ at 750–500 m.

This species has not been taken in the Antarctic Zone before.

Augaptilus sp.

St. 129 ... ... 1 juv. at 950–780 m.
St. 161 ... ... 2 at 500–250 m.
St. WS 67 ... 1 juv. at 1000–750 m.
St. WS 68 ... 2 at 1000–750 m.
St. WS 69 ... 1 at 500–250 m.

Euaugaptilus sp. juv.

St. 11 ... ... 63 at 250–100 m.

Centraugaptilus rattrayi, T. Scott. One male specimen was taken off the west coast of South Georgia at St. 44 at 500–250 m. and one female at St. WS 69, north of the Antarctic Convergence, at 750–500 m. This species has not been taken in the Antarctic Zone before.

Pachyptilus sp.

St. WS 38 ... 1 ♀ at 1000–750 m.

This genus has not been recorded in the Antarctic Zone before.

Phyllopus bidentatus, Brady.

St. 151 ... ... 1 ♀ at 750–500 m.

This and the following species have not before been taken in the Antarctic Zone.

Phyllopus, ? *helgae*, Farran.

St. WS 61 ... 1 at 50–0 m.
St. WS 68 ... 1 ♀ at 750–500 m.

CANDACIIDAE

Candacia falcifera, Farran. Only a single specimen, female, taken at St. 161 far to the south-west of South Georgia at a depth of 1000–750 m.

A few specimens were taken in the Antarctic between 66° 30′ and 76° S. by the 'Terra Nova'.[1]

Candacia sp.n. The late Mr Andrew Scott reported a new species of *Candacia* at the following stations. It was hoped that a description of this species from the notes he left could be published, but unfortunately they are not sufficiently complete.

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[1] Farran (1929).

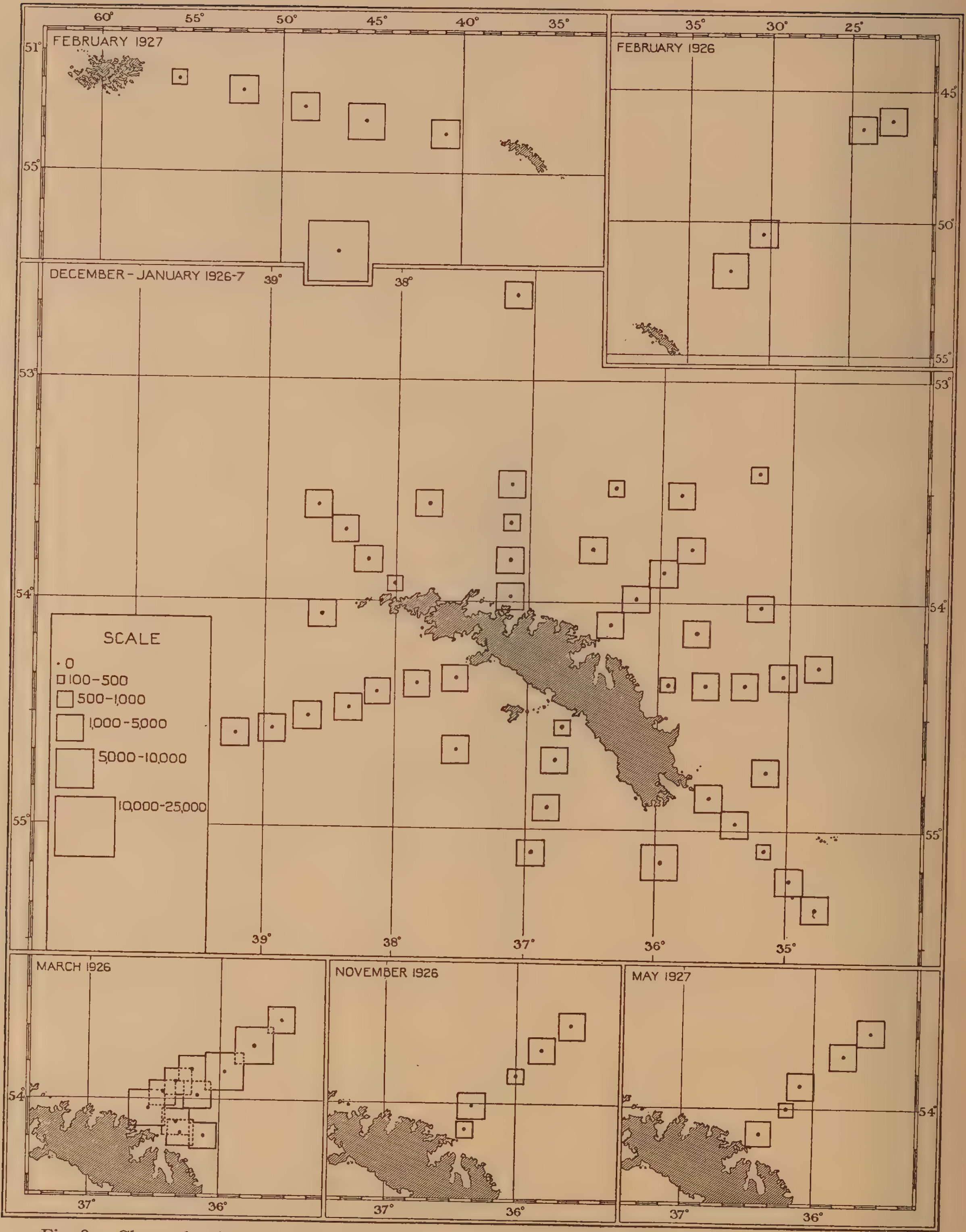

FEBRUARY 1927
60° 55° 50° 45° 40° 35°
51°
55°
FEBRUARY 1926
35° 30° 25°
45°
50°
55°
DECEMBER - JANUARY 1926-7
39° 38°
53°
54°
55°
SCALE
· 0
□ 100-500
500-1,000
1,000-5,000
5,000-10,000
10,000-25,000
39° 38° 37° 36° 35°
MARCH 1926
54°
37° 36°
NOVEMBER 1926
37° 36°
MAY 1927
54°
37° 36°

Fig. 84. Charts showing the distribution of *Oithona frigida* in the upper layers of water at stations in the 1926–7 surveys. The squares represent the average numbers per 50 m. vertical haul with N 70 V nets from 250 m. (or less at shallow-water stations) to the surface. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

St. 11	N 70 V	1	at 250–100 m.	St. WS 69 ...	N 70 V	1 ♀, 17 ♂	at 750–500 m.
St. 36	N 100 H	3 ♀, 1 ♂	at (90–0) m.	St. WS 70 ...	N 70 V	3 ♀, 1 ♂	at 250–100 m.
St. 37	N 100 H	7 ♀, 3 ♂	at (90–0) m.			1 juv., 3 ♀	at 750–500 m.
St. 129	N 70 V	2 ♀	at 750–500 m.	St. WS 110 ...	N 70 V	2 ♀	at 1000–750 m.
St. WS 26 ...	N 70 H	2	at (150) m.	St. WS 111 ...	N 70 V	1 ♀	at 1000–750 m.
St. WS 67 ...	N 70 V	2 ♀	at 1000–300 m.	St. WS 112 ...	N 70 H	1	at (154) m.

It will be seen that it was widely distributed in the area.

Candacia sp. Another species which Mr Scott had not determined was recorded as follows:

St. 12	N 70 V	1	at 100–50 m.	St. WS 30 ...	N 100 H	1 ♀	at (134) m.
St. 151	N 100 H	4 ♂, 2 ♀	at (500–625) m.	St. WS 36 ...	N 70 V	1	at 750–500 m.
St. WS 18 ...	N 100 H	1 ♀	at (0–5) m.	St. WS 38 ...	N 70 V	1 ♀	at 250–100 m.
St. WS 22 ...	N 100 H	1 ♂	at (185) m.	St. WS 41 ...	N 70 H	1	at (55) m.
	N 70 V	1 juv.	at 750–500 m.	St. WS 44 ...	N 70 V	1 ♂	at 750–500 m.
		1 ♀	at 750–500 m.	St. WS 61 ...	N 70 V	1+1 ♀	at 500–250 m.
		1 ♀	at 1000–0 m.			1 ♀	at 750–500 m.
St. WS 30 ...	N 70 V	1	at 100–50 m.	St. WS 70 ...	N 70 V	2 ♂+1 ♀	at 500–250 m.
		1 ♀	at 750–500 m.			4 ♀	at 1000–750 m.

Bathypontia sp.

St. 138... ... 6 ♀ at 2000–1000 m.

The division between the intermediate and the cold Antarctic bottom layer occurred at approximately 1500 m. at this station. The genus has not been recorded in the Antarctic Zone before.

Copepoda Podoplea

Mormonillidae

Mormonilla phasma, Giesbr.

St. 138... ... 6 ♀ at 2000–1000 m.
St. WS 44 ... 1 at 1000–750 m.
St. WS 63 ... 1 ♀ at 750–500 m.

This species has not been recorded from the Antarctic Zone before.

Cyclopidae

The Cyclopidae were represented by three species of the genus *Oithona*, only one of which was abundant.

Oithona frigida, Giesbr. This species formed one of the most constant features of the N 70 V and H samples, and it occurred in large numbers throughout the area. The complete record of its occurrence in the present survey is shown in Appendix II. From this table and Fig. 84 its uniformity of distribution will be seen. At the "control" St. 41, discussed on p. 265, its numbers varied from 1100 to 6900 per 50 m. haul, so that if this criterion is applied to the figures for its horizontal distribution throughout the area, the whole area may be said to have a very uniform population for this species. It was as abundant close against the coast as it was at the outlying stations. There is no difference in numbers in the water of Bellingshausen Sea or Weddell Sea origin. Its vertical distribution round South Georgia is shown in Fig. 85; it is seen to be most

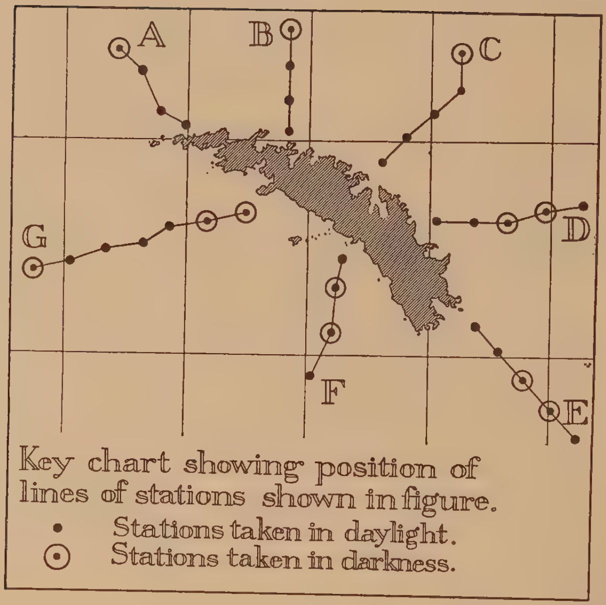
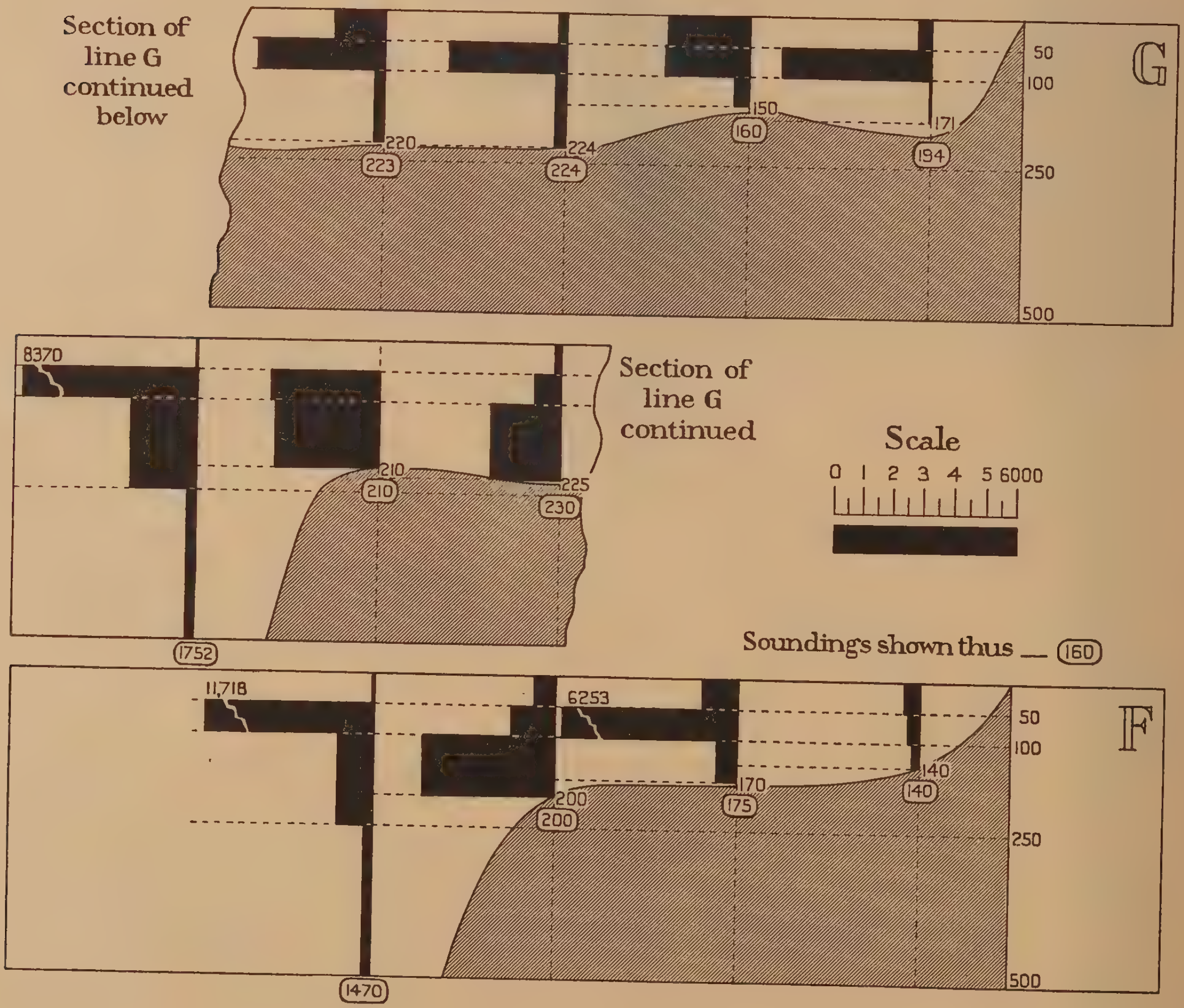

A
B
C
D
E
F
G
Key chart showing position of lines of stations shown in figure.
• Stations taken in daylight.
⊙ Stations taken in darkness.

Fig. 85. Showing the vertical distribution of **Oithona frigida**, Giesbr. down to 500 m. on lines of stations in the South Georgia December-January 1926–7 survey.

The scale represents the numbers per 50 m. vertical haul taken by closing (N 70 V) nets in a series of hauls: 500–250, 250–100, 100–50 and 50–0 m. (as far as depth will allow). For distribution at greater depths see Appendix II. For accompanying hydrological conditions see Figs. 7 and 8.



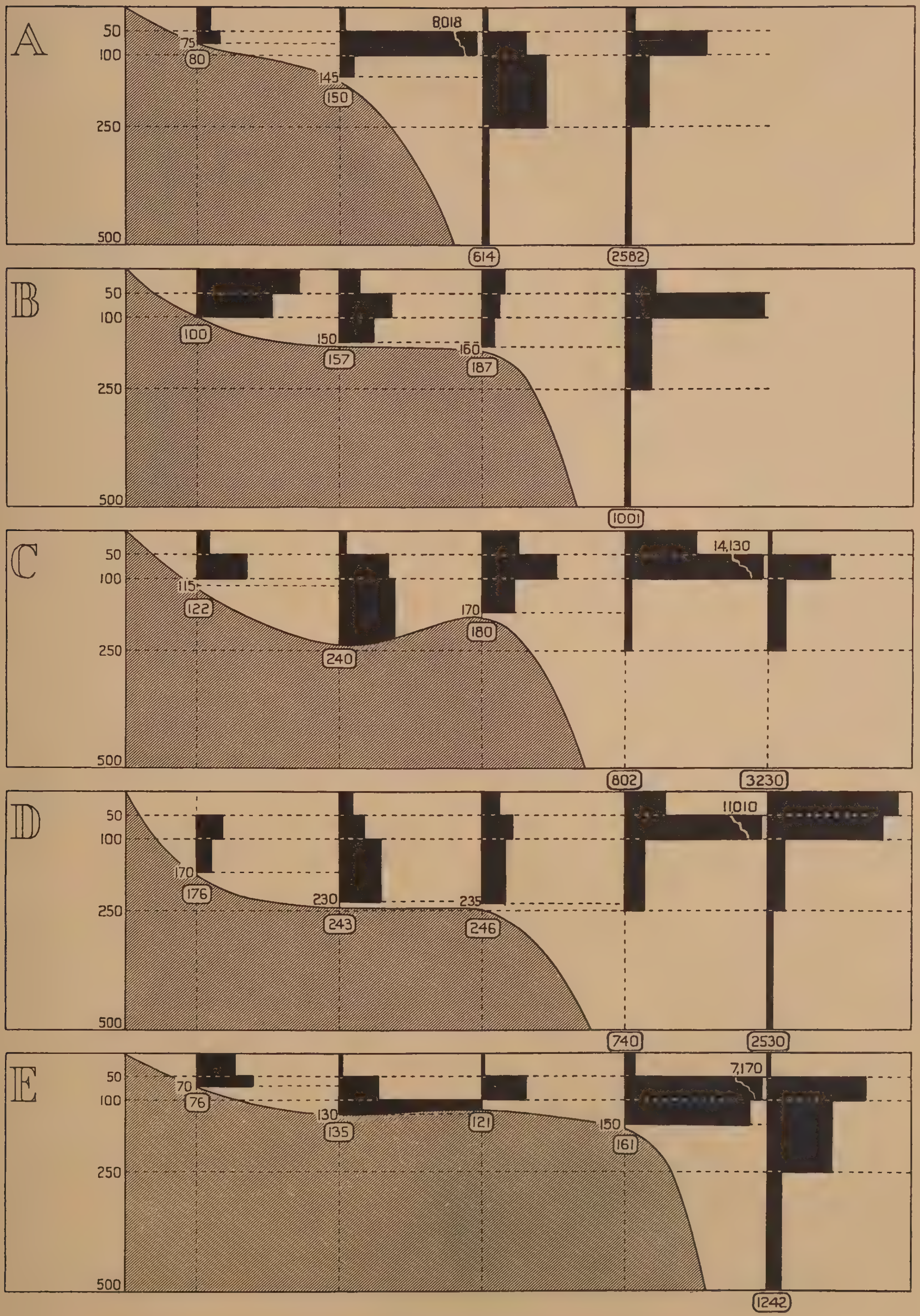


Fig. 85—*continued*

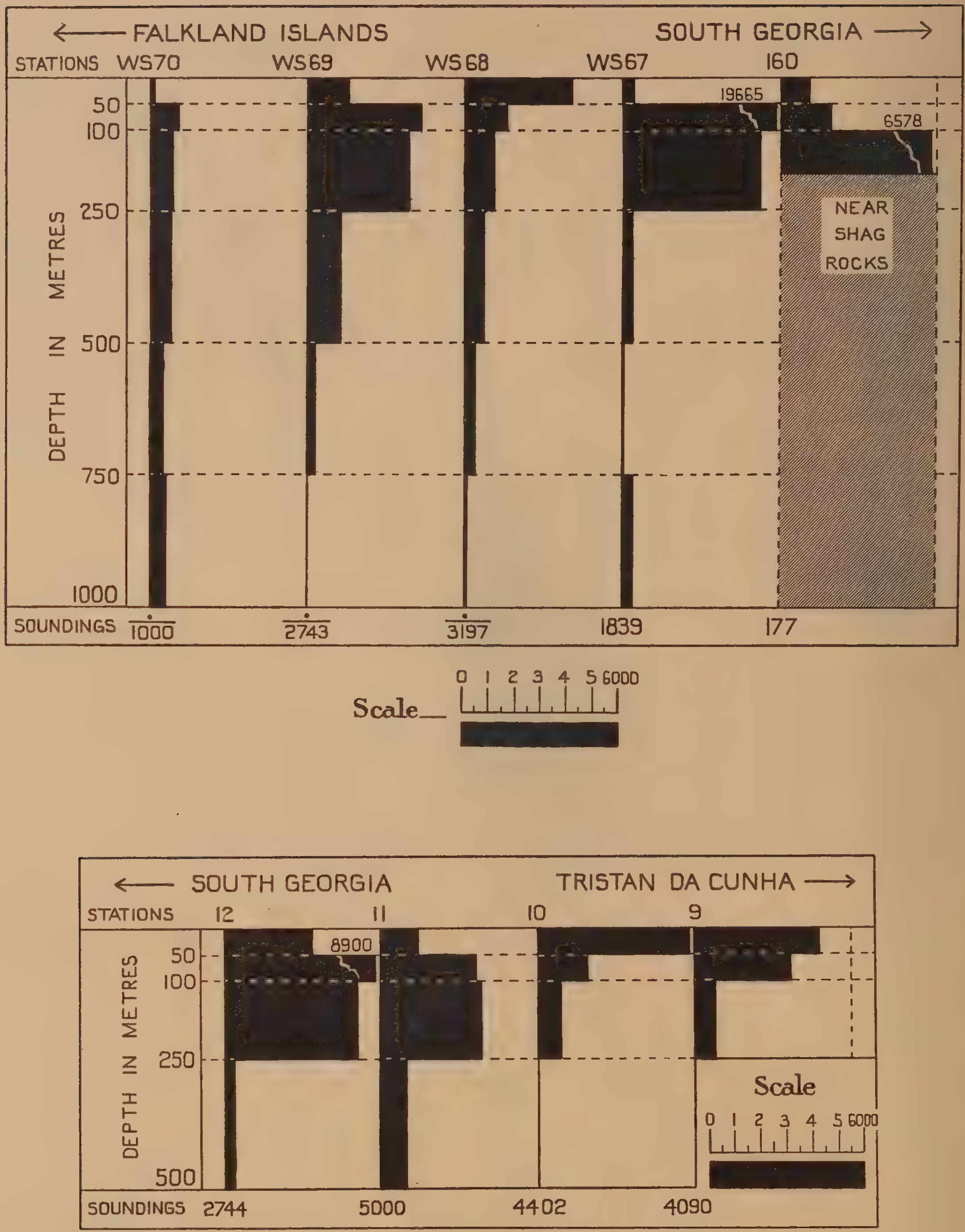


Fig. 86. Showing the vertical distribution of *Oithona frigida* at stations between the Falkland Islands and South Georgia February 1927 and between South Georgia and Tristan da Cunha February 1926. The scale represents the numbers per 50 m. vertical haul taken by a series of closing N 70 V nets. Horizontal broken lines show the ranges of these vertical hauls. For accompanying hydrological conditions see Figs. 9 and 10.

abundant between 100 and 50 m. depths, but a few specimens have been recorded between depths of 2000 and 1000 m. Its vertical distribution on the oceanic lines is shown in Fig. 86. Its mean vertical distribution at deep-water stations is shown in Fig. 56. It showed no evidence of a diurnal vertical migration, see Figs. 110 and 113.

In seasonal distribution it was more abundant in the late summer and autumn than in spring and early summer; this is further discussed in relation to other forms on p. 266.

O. frigida was first described by Giesbrecht (1902) from the Belgica collections. It was taken at seven stations in the pack ice by the Gauss[1] Expedition. Brady (1918), in his report of the Aurora collections, writes that "most of the gatherings contained species belonging to the genus *Oithona*, but I am unable certainly to identify them except in three cases. Most of the species may, I think, be referred to *O. frigida*". Farran (1929), in his report of the Terra Nova collections, writes that *O. frigida* was "only found within the Antarctic Circle and most numerous in hauls beneath the ice". On the other hand, he finds that *O. similis* was common over the whole area traversed from New Zealand to the ice barrier. It is curious that in our area the place of *O. similis* appears to be taken by *O. frigida*. Mr Scott only recorded *O. similis* at one station, and that outside the Antarctic Zone, see below.

Oithona similis, Claus. Only recorded at one station in deep water towards the Falkland Islands, i.e. north of the Antarctic Convergence.

St. WS 69 ... 124 at 1000–750 m.

It is remarkable that we have no records south of the line of Antarctic Convergence since it was taken in the Antarctic by the 'Belgica',[2] 'Gauss'[1] and 'Terra Nova',[3] the last expedition taking it as far south as 78° S. See note above under *O. frigida*.

Oithona sp.

St. 125 ... ... 42 at 250–100 m.
St. 129 ... ... 50 at 100–50 m.
St. 131 ... ... 46 at 100–50 m.
St. 132 ... ... 6 at 50–0 m.
14 at 100–50 m.
30 at 170–125 m.
62 at 170–0 m.
St. 133 ... ... 10 at 50–0 m.
30 at 100–50 m.
7 at 270–100 m.
St. 135 ... ... 17 at 50–0 m.
30 at 100–50 m.

St. 137 ... ... 90 at 100–50 m.
St. 138 ... ... 20 at 100–50 m.
St. 151 ... ... 25 at 100–50 m.
St. 161 ... ... 12 at 500–250 m.
St. WS 37 ... 80 at 250–100 m.
St. WS 42 ... 8 at 170–100 m.
St. WS 44 ... 60 at 250–100 m.
St. WS 48 ... 4 at 224–100 m.
St. WS 50 ... 240 at 100–50 m.
St. WS 52 ... 15 at 180–100 m.
St. WS 63 ... 13 at 250–100 m.

HARPACTICIDAE

Microsetella norvegica (Boeck).

St. 136 .. ... 20 at 50–0 m.
St. WS 45 ... 16 at 170–0 m.

It was taken in the Antarctic by the 'Terra Nova'[3] and the 'Aurora'.[4]

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[1] Wolfenden (1911).
[2] Giesbrecht (1902).
[3] Farran (1929).
[4] Brady (1918).

Clytemnestra rostrata, Brady. Only recorded at stations outside the Antarctic Zone, approaching South Georgia from the north-east.

St. 9	1 ♀	at 100–50 m.
	1 ♂, 2 ♀	at 250–100 m.
St. 10	2 ♂, 1 ♀	at 250–100 m.

ONCAEIDAE

The Oncaeidae were represented by four species of the genus *Oncaea* and by one species each of the genera *Conaea* and *Lubbockia*.

Oncaea conifera, Giesbr. This species was widely distributed throughout the area, ranging in depth from the surface to over 1000 m. It occurred at St. 69 beyond the line of the Antarctic Convergence. The following is a record of its occurrence:

St. 11	1 ♀	at 500–250 m.
St. 12	65 ♀	at 500–250 m.
St. 17	34 ♀	at 500–250 m.
St. 21	6 ♀	at 100–50 m.
St. 41 B ...	1 ♀	at 50–0 m.
St. 124... ...	3	at 210–100 m.
St. 125... ...	78	at 500–250 m.
	84	at 750–500 m.
	1	at 1000–750 m.
St. 126... ...	3102	at 50–0 m.
St. 129... ...	4	at 500–250 m.
	136	at 750–500 m.
	683 ♂	at 950–780 m.
	455 ♀	at 950–780 m.
St. 131... ...	2	at 100–50 m.
St. 133... ...	4	at 500–250 m.
	1	at 750–500 m.
St. 137... ...	257	at 250–100 m.
	123	at 700–500 m.
St. 138... ...	180	at 500–250 m.
	64	at 750–500 m.
	187	at 1000–750 m.
	2104 ♀	at 2000–1000 m.
St. 139... ...	1	at 50–0 m.
St. 160... ...	4	at 180–100 m.
St. 161... ...	289	at 500–250 m.
	60	at 750–500 m.
	30	at 1000–750 m.
St. WS 22 ...	20	at 250–100 m.
	196	at 500–250 m.
	180	at 750–500 m.
	594	at 1000–750 m.
	496	at 1000–0 m.
St. WS 26 ...	141	at 750–0 m.
	130	at 750–500 m.
	113	at 1000–750 m.
St. WS 28 ...	2	at 50–0 m.
St. WS 30 ...	59	at 250–100 m.
	406	at 500–250 m.
	606	at 500–330 m.
	638	at 750–500 m.
	20	at 1000–750 m.
St. WS 36 ...	10	at 50–0 m.
	339	at 500–250 m.
	120	at 750–500 m.
	82	at 1000–750 m.
St. WS 37 ...	16	at 50–0 m.
	9	at 250–100 m.
	112	at 310–250 m.
St. WS 38 ...	169	at 500–250 m.
	165	at 750–500 m.
	635	at 1000–750 m.
St. WS 44 ...	42	at 100–50 m.
	389	at 1000–750 m.
St. WS 46 ...	2	at 50–0 m.
St. WS 49 ...	13	at 225–100 m.
St. WS 61 ...	16	at 50–0 m.
St. WS 63 ...	380	at 750–500 m.
St. WS 67 ...	11	at 250–100 m.
	3	at 750–500 m.
	3	at 1000–750 m.
	2	at 1000–300 m.
St. WS 68 ...	233	at 750–500 m.
	2	at 1000–750 m.
St. WS 69 ...	63	at 500–250 m.
	5	at 750–500 m.
	1435 juv.	at 1000–750 m.
St. WS 110...	1993	at 1000–750 m.

The 'Terra Nova'[1] found this species common off New Zealand and extending southward to latitude 77° S., where it was taken in hauls beneath the ice. The 'Gauss'[2] found it spread widely from the ice in the south to the North Atlantic. It was also taken by the 'Belgica'.[3]

Oncaea curvata, Giesbr. This species was also widely distributed throughout the area, but rarely occurred at levels above 100 m. depth and was never found in the top 50 m.

St. 11	N 70 V	254♀	at	250–100 m.
		660♀	at	500–250 m.
St. 12	N 70 V	210♀	at	250–100 m.
		525♀	at	500–250 m.
St. 16	N 70 V	3♀	at	500–250 m.
St. 17	N 70 V	446♀	at	500–250 m.
St. 41 A	N 70 V	1860♀	at	265–150 m.
St. 41 B	N 70 V	200♀	at	250–150 m.
St. 41 C	N 70 V	25	at	150–100 m.
		300	at	240–150 m.
St. 41 D	N 70 V	1320	at	240–150 m.
St. 41 E	N 70 V	50	at	150–100 m.
		360	at	250–150 m.
St. 124	N 70 H	600	at	130 m.
St. 125	N 70 V	3	at	500–250 m.
		6	at	750–500 m.
St. 127	N 70 V	1	at	150–110 m.
St. 128	N 70 V	14	at	160–100 m.
St. 129	N 70 V	303	at	500–250 m.
St. 133	N 70 V	24	at	750–500 m.
St. 135	N 70 V	2	at	100–50 m.
St. 136	N 70 V	227	at	235–100 m.
St. 137	N 70 V	342	at	250–100 m.
		3	at	500–250 m.
		184	at	700–500 m.
St. 138	N 70 V	42	at	100–50 m.
		162	at	500–250 m.
		3♀	at	2000–1000 m.
St. 139	N 70 V	1	at	250–150 m.
St. 151	N 70 V	123	at	750–500 m.
St. 161	N 70 V	237	at	250–100 m.
		5	at	500–250 m.
St. WS 20	N 70 V	146	at	500–250 m.
St. WS 22	N 70 V	3	at	500–250 m.
	N 70 H	100	at	165 m.
St. WS 24	N 70 V	900	at	200–100 m.
St. WS 26	N 70 V	8	at	100–50 m.
		6	at	500–250 m.
St. WS 29	N 70 V	95	at	600–500 m.

St. WS 30	N 70 V	378	at	500–330 m.
St. WS 36	N 70 V	407	at	500–250 m.
		240	at	750–500 m.
St. WS 37	N 70 V	73	at	250–100 m.
		560	at	310–250 m.
St. WS 38	N 70 V	33	at	750–500 m.
St. WS 40	N 70 V	1619	at	175–100 m.
St. WS 41	N 70 V	360	at	140–100 m.
St. WS 42	N 70 V	135	at	100–50 m.
St. WS 43	N 70 V	202	at	200–100 m.
St. WS 44	N 70 V	83	at	250–100 m.
		2	at	500–250 m.
		2	at	750–500 m.
St. WS 48	N 70 V	119	at	224–100 m.
St. WS 50	N 70 V	15	at	100–50 m.
St. WS 51	N 70 V	170	at	200–100 m.
St. WS 52	N 70 V	4	at	180–100 m.
St. WS 63	N 70 V	485	at	250–100 m.
		1537	at	500–250 m.
		177	at	750–500 m.
St. WS 67	N 70 V	2	at	500–250 m.
		38	at	750–500 m.
		14	at	1000–750 m.
		410	at	1000–300 m.
St. WS 68	N 70 V	1	at	250–100 m.
		27	at	500–250 m.
		47	at	750–500 m.
St. WS 69	N 70 V	82	at	250–100 m.
		140	at	500–250 m.
		194	at	750–500 m.
St. WS 70	N 70 V	28	at	50–0 m.
		19	at	750–500 m.
St. WS 110	N 70 V	1	at	100–50 m.
		581	at	500–300 m.
		1	at	750–500 m.
		20	at	1000–750 m.
St. WS 111	N 70 V	4	at	500–250 m.
		309	at	750–500 m.
		173	at	1000–750 m.

This species was taken in the Antarctic by the 'Belgica',[3] 'Gauss'[2] and 'Terra Nova',[1] the last-named expedition finding it frequently under the ice at winter quarters.

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[1] Farran (1929). [2] Wolfenden (1911). [3] Giesbrecht (1902).

Oncaea notopus, Giesbr. This species was also of general distribution but occurred in particularly large numbers to the west of South Georgia, extending across the line of Antarctic Convergence towards the Falkland Islands. It occasionally occurred in the top 50 m. but was most abundant at the deeper levels.

St. 11	63♀	at	250–100 m.
	33♀	at	500–250 m.
St. 12	262♀	at	500–250 m.
St. 17	2♀	at	750–500 m.
St. 124	21	at	210–100 m.
St. 125	554	at	500–250 m.
	526	at	750–500 m.
	1042	at	1000–750 m.
St. 128	2	at	100–50 m.
	27	at	160–100 m.
St. 129	1111	at	500–250 m.
	1437	at	750–500 m.
	11	at	950–780 m.
St. 133	3	at	500–250 m.
	8	at	750–500 m.
St. 136	796	at	235–100 m.
St. 137	1412	at	250–100 m.
	6	at	500–250 m.
	394	at	700–500 m.
St. 138	70	at	100–50 m.
	386	at	250–100 m.
	838	at	500–250 m.
	151	at	750–500 m.
	1♀	at	1000–750 m.
	373	at	1000–750 m.
	105♀	at	2000–1000 m.
St. 139	2	at	50–0 m.
	2	at	250–150 m.
St. 151	165	at	500–250 m.
	375	at	750–500 m.
	495	at	1000–750 m.
St. 161	1	at	100–50 m.
	1353	at	500–250 m.
	665	at	750–500 m.
	120	at	1000–750 m.
St. WS 20	29	at	500–250 m.
St. WS 21	110	at	500–250 m.
	17	at	750–500 m.
St. WS 22	1	at	50–0 m.
	613	at	500–250 m.
	9	at	1000–0 m.
	1	at	1000–750 m.
St. WS 26	392	at	500–250 m.
	2330	at	750–0 m.
	2088	at	750–500 m.
	160	at	1000–750 m.
St. WS 27	9	at	50–0 m.
St. WS 28	1	at	50–0 m.
St. WS 29	785	at	500–250 m.
	245	at	600–500 m.
St. WS 30	6	at	50–0 m.
	126	at	250–100 m.
	1685	at	500–250 m.
	14	at	1000–750 m.
St. WS 36	231	at	500–250 m.
	1091	at	750–500 m.
	72	at	1000–750 m.
St. WS 37	278	at	310–250 m.
St. WS 38	538	at	500–250 m.
	110	at	750–500 m.
	426	at	1000–750 m.
St. WS 40	3	at	100–50 m.
St. WS 42	203	at	170–100 m.
St. WS 44	32	at	250–100 m.
	3	at	500–250 m.
St. WS 48	3	at	224–100 m.
St. WS 51	23	at	200–100 m.
St. WS 52	4	at	180–100 m.
St. WS 61	4076	at	500–250 m.
	1316	at	1000–750 m.
St. WS 63	320	at	750–500 m.
	660	at	1000–750 m.
St. WS 67	1098	at	500–250 m.
	107	at	750–500 m.
	8	at	1000–750 m.
	1688	at	1000–300 m.
St. WS 68	1	at	250–100 m.
	81	at	500–250 m.
	186	at	750–500 m.
	438	at	1000–750
St. WS 69	122	at	250–100 m.
	529	at	500–250 m.
	2069	at	750–500 m.
St. WS 70	485	at	50–0 m.
	204	at	100–50 m.
	362	at	250–100 m.
	403	at	500–250 m.
	2073	at	750–500 m.
	1010	at	1000–750 m.
St. WS 110	250	at	500–300 m.
	53	at	750–500 m
	654	at	1000–750 m.
St. WS 111	217	at	250–100 m.
	552	at	500–250 m.
	610	at	750–500 m.
	1092	at	1000–750 m.
St. WS 111–112A	94	at	50–0 m.

This species was taken in the Antarctic by the Belgica[1] Expedition.

Oncaea sp.

St. 10	N 70 V	40	at	100–50 m.	St. WS 51 ...	N 70 H	300	at	119 m.
St. 17	N 70 V	200	at	50–0 m.					

Oncaea spp. juv.

St. 128	N 70 V	14	at	160–100 m.	St. WS 44 ...	N 70 V	956	at	250–100 m.
St. 133	N 70 V	42	at	270–100 m.			462	at	500–250 m.
St. 135	N 70 V	87	at	230–100 m.			1236	at	750–500 m.
St. 151	N 70 V	5	at	750–500 m.			449	at	1000–750 m.
		2	at	1000–750 m.	St. WS 45 ...	N 70 V	29	at	170–100 m.
St. 160	N 70 V	2	at	100–50 m.	St. WS 49 ...	N 70 V	107	at	225–100 m.
St. WS 19 ...	N 70 V	1	at	100–0 m.	St. WS 54 ...	N 70 V	237	at	100–0 m.
St. WS 20 ...	N 70 V	212	at	250–100 m.			187	at	500–250 m.
St. WS 22 ...	N 70 V	506	at	500–250 m.	St. WS 61 ...	N 70 V	3	at	500–250 m.
St. WS 29 ...	N 70 V	447	at	250–100 m.			563	at	750–500 m.
St. WS 38 ...	N 70 V	946	at	750–500 m.			3	at	1000–750 m.
St. WS 40 ...	N 70 V	2	at	100–50 m.	St. WS 63 ...	N 70 V	1064	at	500–250 m.
St. WS 43 ...	N 70 H	250	at	62 m.	St. WS 67 ...	N 70 V	32	at	750–500 m.
	N 70 V	53	at	100–50 m.	St. WS 69 ...	N 70 V	10	at	1000–750 m.
	N 70 H	800	at	124 m.					

Conaea rapax, Giesbr. Only recorded at two stations to the east of South Georgia in deep water.

St. 129	7♀	at	950–780 m.	St. 138	1	at	2000–1000 m.

It has not before been recorded in the Antarctic Zone.

Lubbockia, ? *glacialis*, Sars.

St. 125	4♀	at	1000–750 m.	St. WS 67 ...	1	at	1000–300 m.

This species has also not been recorded in the Antarctic Zone before.

Cirripedia

Cypris larvae occurred at the following stations:

St. 129	1 at 0–5 m.	St. WS 70	1 at 172 m.
St. 150[2] ...	1–20 at 0–5 m.	St. WS 110	200 at 0–5 m.
St. WS 52 ...	100 at 108 m.		101 at 62 m.
St. WS 53	1 at 0–5 m.	St. WS 111	500 at 84 m.
St. WS 63	400 at 161 m.	St. WS 112	1 at 0–5 m.
St. WS 66	1 at 0–5 m.		200 at 154 m.
	1 at 88 m.	St. WS 113	301 at 0–5 m.
St. WS 67	1 at 0–5 m.	St. WS 114	400 at 0–5 m.
	1 at 132 m.		168 at 58 m.
St. WS 68	1 at 80 m.		1504 at 116 m.
St. WS 69	1 at 146 m.		

Sts. WS 52 and WS 63 lie not far distant from one another to the west and north-west of South Georgia, and were both taken in January. Sts. WS 110–114, at which these larvae formed a prominent feature of the plankton, were all taken off the north-east coast of South Georgia in late May, i.e. late in the southern autumn.

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[1] Giesbrecht (1902).

[2] Consecutive Net Series 0–5 m. depth.

PART IV. THE ZOOPLANKTON

SECTION II

By A. C. Hardy, M.A. and E. R. Gunther, M.A.

DISTRIBUTION (*cont.*)

CRUSTACEA (*cont.*)

Amphipoda

Examples of the different species of Amphipod taken in our samples were submitted to Dr K. H. Barnard, who kindly identified them for us.

Parathemisto (*Euthemisto*) *gaudichaudi* (Guér.). This species was by far the most prominent planktonic Amphipod within the area, occurring in particularly large numbers off the north-east coast of South Georgia in March 1926. Here it was found to be feeding largely upon young Euphausians and no doubt, considered ecologically, it is a very important element in the plankton community.

Out of the fifty-three stations in the survey round the island in December and January 1926–7, it was taken at all but four, and at some stations, again off the north-east coast, it was present in very large numbers but not equalling those of the preceding March. From the results of this survey it would seem that it is more abundant in water of Weddell Sea origin than in that of Bellingshausen Sea origin; but before coming to a conclusion on this, the hypothesis of animal exclusion, discussed in Part V, should be considered, for we have seen that to the south-west there is a particularly heavy production of phytoplankton.[1] The two series of consecutive net hauls taken off the north-east coast in January 1926, and described and illustrated on p. 254 and Fig. 133, showed that this species was very patchy in its distribution. At first sight this might seem to have a very serious effect upon our conception of its distribution. But the length of tow of the nets in the consecutive net series was half a mile only, whereas at each station in the December-January survey the nets were towed for a whole mile, and in the previous March for 3 miles. A tow of 1 mile is likely to cut through a patch, and at each station there was a series of three nets one below the other approximately 50 m. apart.

Again, the species exhibits a marked vertical migration, rising towards the surface in large numbers in the hours of darkness; this is described and illustrated on p. 237 and Fig. 121. Whilst the chart of distribution in Fig. 87 is based upon three net hauls taken at different levels at each station, the massing of these Amphipods at the surface during the night should be kept in mind, and the chart of distribution should be compared with Fig. 89, which shows the stations taken in the hours of darkness.

[1] The collection of Amphipods sent to Dr Barnard for treatment in his systematic report did not include all the specimens of the commoner species, but only samples, and by being sent only specimens from the north-east side of the island it is most unfortunate that he should have been misled into believing that "not a single pelagic Amphipod was captured on the south-west side of South Georgia" (see p. 25 of his Report). Reference to Fig. 87 will show that this is not so.

The vertical range of the species may be gauged from the N 70 V net results. Whilst it may very occasionally be taken from depths below 500 and even 750 m. it is essentially an inhabitant of the upper layers, the largest numbers being found in the top 100 m. This depth distribution is shown in the following table which includes all the net hauls taken exactly between our standard depth intervals, but excludes odd hauls, for example 165–100 m., which do not cover a standard depth range.

Table XXII

The depth distribution of Parathemisto gaudichaudi *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	498	84	118·5
100–50	1152	81	284·4
250–100	190	33	38·4
500–250	18	29	2·5
750–500	7	21	1·3
1000–750	2	17	0·5

This table may conveniently be compared with the figures showing the range of temperature and salinity within the area, Figs. 7 and 8, when its preference for the cold surface layer will be clearly seen.

This species is not confined to the Antarctic Zone; on the two oceanic lines of stations it was taken in the largest numbers in the sub-Antarctic Zone; at St. 9 on the line approaching South Georgia from the north-east in February 1926, see Appendix II (these N 70 V results are not given in Fig. 87), and at St. 70 on the line between South Georgia and the Falkland Islands taken in February 1927, as shown in Fig. 87. It was taken by the National Antarctic (Discovery) Expedition (Walker, 1907) abundantly between 54° and 63° S and by the British Antarctic (Terra Nova) Expedition (Barnard, 1930) from 48° 30′ S to 66° 45′ S. It has a similar range in the northern hemisphere, but may be taken in small numbers in the tropics, for the Plankton Expedition took a single specimen in 7° S (Vosseler, 1901).

Little can be said regarding its seasonal distribution from the material at present available, but we may note that it was not so abundant on the line taken in November 1926 and May 1927 as it was in December 1926, January 1927, or March 1927. Barnard (1932) states that "breeding takes place in the southern spring and summer, ovigerous ♀♀ being caught in November, December and February, and on two occasions ♀♀ with embryos in October". He found that the two forms *compressa* and *bispinosa* occurred together.

A complete record of the occurrence of the species in the area is given in Appendix II.

Hyperoche medusarum (Krög.). This species was met with at many stations round South Georgia, but was never abundant; it occurred also at St. WS 69 and WS 70 in

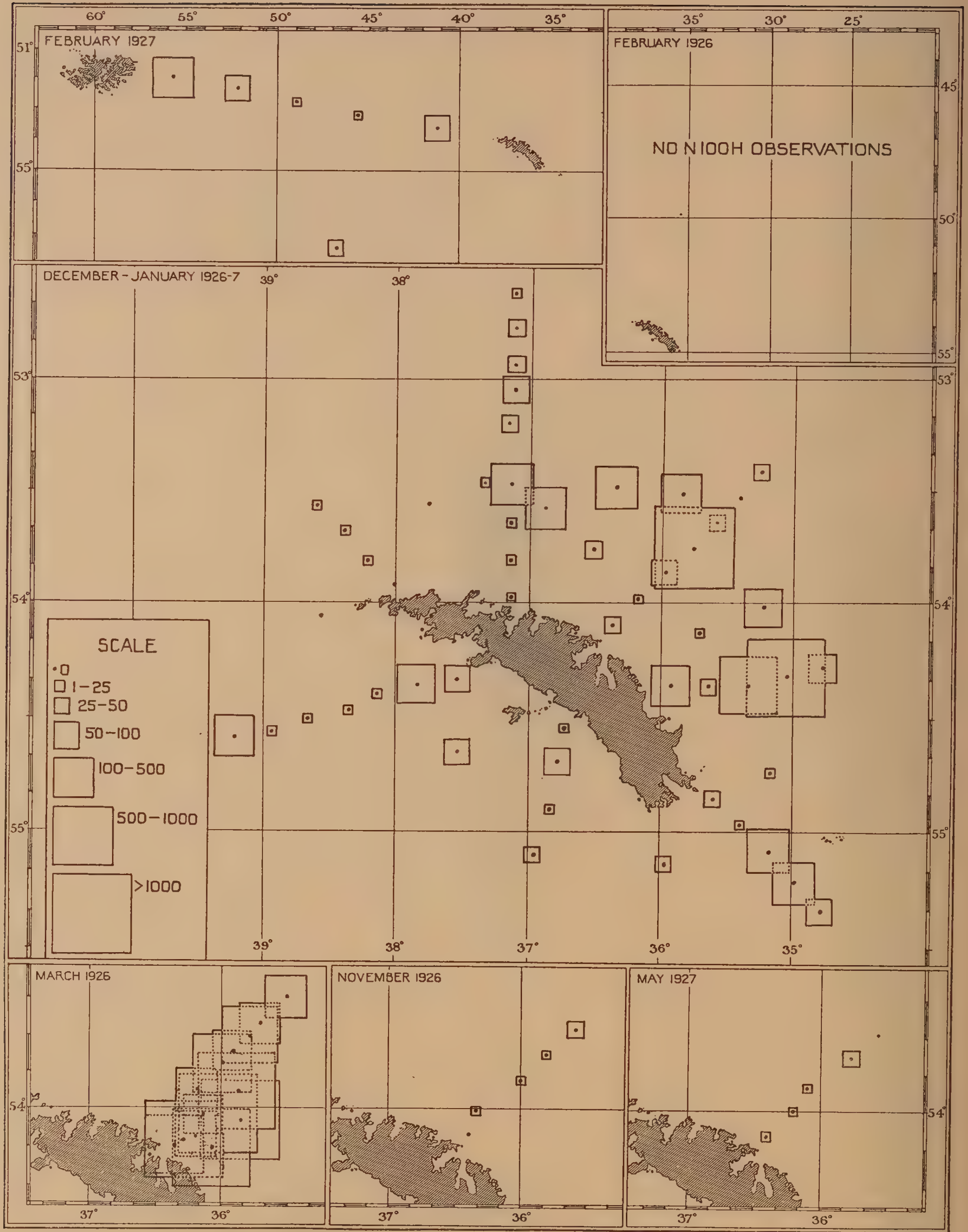
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
NO N 100H OBSERVATIONS
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
0
1-25
25-50
50-100
100-500
500-1000
>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 87. Charts showing the distribution of *Parathemisto gaudichaudi* at stations in the 1926–7 surveys. The squares represent the numbers taken in three N 100 H nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

the sub-Antarctic Zone towards the Falkland Islands. It is confined to the upper layers, both the cold Antarctic surface layer and the sub-Antarctic surface layer across the line of Convergence. The following is a statement of its occurrence:

St. 124	4 at	180–90 m.
St. 125	4 at	0–5 m.
St. 127	1 at	82 m.
St. 128	6 at	95 m.
St. 129	17 at	0–5 m.
	1 at	44 m.
	4 at	88–0 m.
St. 131	8 at	124 m.
St. 132	7 at	90 m.
St. 136	4 at	96 m.
St. 137	1 at	0–5 m.
St. 139	1 at	0–5 m.
St. 150[1]	2 at	0–5 m.
St. WS 18	6 at	0–5 m.
	12 at	46 m.
	4 at	128 m.
St. WS 20	3 at	164 m.

St. WS 21	10 at	0–5 m.
	3 at	90 m.
	2 at	192 m.
St. WS 22	7 at	165 m.
St. WS 24	15 at	0–5 m.
	18 at	117 m.
St. WS 29	30 at	131 m.
St. WS 30	5 at	100–5 m.
St. WS 33	21 at	97 m.
St. WS 34	1 at	80 m.
St. WS 38	21 at	0–5 m.
St. WS 46	1 at	87 m.
St. WS 49	2 at	161 m.
St. WS 53[1]	4, 1, 1, 1, 1	
St. WS 69	1 at	55 m.
St. WS 70	14 at	0–5 m.

This species has not been taken in the Antarctic before. Barnard (1932) writes: "It is extremely interesting to find this boreo-Arctic species appearing in the South Georgia area", and gives its northern distribution as "North Atlantic and adjacent seas, about 50–77° N and north of Alaska".

Pseudorchomene coatsi, Chilton. This species only occurred at two stations off the north-east coast of South Georgia:

St. 129	1 at	0–5 m.
	12 at	84–0 m.
St. 130	1 at	38 m.

It was also recorded by Barnard (1932) from trawl hauls in the same region. Many specimens were taken by the 'Scotia' (Chilton, 1912) off Coats Land in lat. 71° 1′ S and by the 'Gauss' (Spandl, 1927) at their winter stations, approx. 66° S.

Primno macropa Guér. This cosmopolitan species was widely distributed in the area, but was never taken in large numbers. A complete record of its occurrence is given in Appendix II. Barnard (1932) writes that it "appears to be principally rather a deep-water species (500–1000 m. or more)". The following table gives its depth distribution as shown by the N 70 V nets, where it will be seen that whilst on occasions it may be taken in the cold polar surface layer it is truly an inhabitant of the warmer water below, and appears to be evenly distributed from 100 to 1000 m. This table should be compared with the temperature and salinity curves in Figs. 7 and 8.

Reference to the N 100 H tables in Appendix II will also show that it is more usually taken in the lowest of the series of three nets. The numbers in these nets are small, and we were not able to detect an indication of vertical migration: out of fifty-eight stations in daylight at which a series of two or more N 100 H nets were used *Primno* was taken at twenty-three, and out of twenty-eight stations taken during hours of darkness *Primno* was taken at six stations. Dr N. A. Mackintosh, who has worked with a larger quantity of material collected over a wider area in the more recent surveys, and who has recently published his results (1934), has found *Primno* to exhibit a migration the reverse of that usual in zooplankton organisms, rising towards the upper layers in daylight. Our figures tend to support this very interesting discovery, especially the fact that out of these twenty-three stations at which it occurred during the day it was taken at the surface at seven of them, whereas it was taken at the surface at night on only one occasion. In the consecutive net series taken at the surface at St. 150, which started at 1700 o'clock, 3 hours before sunset, and proceeded until 0600 o'clock the following morning, 2 hours after sunrise (0355), *P. macropa* does not appear in the nets until that towed between 0300 and 0315 o'clock, and then it occurs in seven other hauls, all of which are after sunrise.

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[1] Consecutive net series.

Table XXIII

The depth distribution of Primno macropa *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	3	84	0·7
100–50	14	81	3·5
250–100	39	33	7·8
500–250	55	29	7·6
750–500	37	21	7·0
1000–750	(31)	17	(7·3)

The species has been taken in the Antarctic before by the Belgica (Monod, 1926) Gauss (Spandl, 1927), and Terra Nova (Barnard, 1930) Expeditions; the first-named taking it as far south as 71° 51′ S, 87° 27′ W.

Vibilia antarctica, Stebb. This species takes second place in importance amongst the pelagic Amphipods of this region. It occurred at most stations, and at times was moderately abundant. A complete record of its occurrence is given in Appendix II. The largest catch was made with the N 100 H net at St. WS 69 across the line of Antarctic Convergence towards the Falkland Islands, when 227 were taken near the surface; and at the next station, WS 70, eighty-four specimens were taken in the surface net.

Its vertical range of distribution is shown in the following table based upon N 70 V net results, when it is seen to inhabit the cold surface layer and a mixture of this water with the warmer layer below down to a depth of 500 m.

It exhibits a vertical diurnal migration towards the surface during the hours of darkness; this phenomenon is discussed and illustrated on pp. 237 and 251.

Table XXIV

The depth distribution of Vibilia antarctica *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	20	84	4·6
100–50	15	81	3·7
250–100	17	33	3·4
500–250	52 (21)*	29	7·2 (2·9)*
750–500	1	21	0·2
1000–750	0	17	0

* Excluding one exceptionally high catch of thirty-one in a single haul at St. 17.

An association appears to exist between this Amphipod and the Salp *Salpa fusiformis*. Three distinct pieces of evidence support this assumption. *Vibilia* or *Salpa* were taken by the N 100 H nets at sixty-one stations. The two occurred together at forty-seven stations (77 per cent); at only ten stations (16·5 per cent) was *Salpa* taken without *Vibilia*, and here the numbers of *Salpa* taken were small (1, 1, 1, 2, 3, 4, 4, 5, 14 and 16) and at only four stations (6·5 per cent) did *Vibilia* occur without *Salpa*, and here again the numbers of *Vibilia* were small (1, 1, 2 and 5). This evidence may be studied in detail in the table of N 100 H results in Appendix II. At St. WS 38 enormous quantities of *Salpa fusiformis*, estimated at 10,730, were taken in the surface net; the material was carefully looked over before being thrown away, for only fractions could be preserved, and ninety-one specimens of *Vibilia* were found. A second piece of evidence may be found in the comparison of the vertical migration charts for *Salpa* and *Vibilia*, Figs. 123 and 124, where it will be seen that the two curves follow one another very closely. The third piece of evidence, and we believe the most important, comes from a study of the patchiness in distribution of the two forms as revealed by the two consecutive net series. These results are described and illustrated on p. 256 and in Fig. 135, where it will be seen that the patches of the two organisms follow one another closely in position and magnitude. Earlier in the voyage we witnessed the association of the Copepod *Sapphirina* with *Salpa democratica*; we saw these Copepods entering the Salps and living inside them, feeding upon the food collected on the endostyle, and one is tempted to imagine that there is either a similar association here or that *Vibilia* is definitely preying upon the Salps themselves. Mr F. C. Fraser has kindly informed us that whilst examining a plankton sample from a later collection (St. WS 376, N 70 V, 250–100 m.) he has found a specimen of *Vibilia* inside one of *Salpa fusiformis*; of course this inclusion may have occurred accidentally in the close mixing of the material in the collecting bucket.

Barnard (1932) describes *Vibilia* as a "typical Antarctic and sub-Antarctic species". It has been taken in the Antarctic by the National Antarctic (Discovery),[1] Scotia,[2] Gauss[3] and Terra Nova[4] Expeditions.

[1] Walker (1907). [2] Chilton (1912). [3] Behning (1927). [4] Barnard (1930).

Cyllopus magellanicus, Dana. and *C. lucasii*, Bate. The genus *Cyllopus* is confined to the southern hemisphere, and has not been taken north of 30° S. We have not distinguished the species in our analyses, but Dr Barnard has informed us that both *C. magellanicus* and *C. lucasii* are present in our collections in the region. They were widely distributed but only occasionally abundant; a complete record of the occurrence of the genus is given in Appendix II. Barnard (1932) states that *C. lucasii* is the more southerly form. Whilst the numbers taken in our N 70 V nets were small they indicate that the genus belongs to the cold Antarctic surface layer and a mixture of this water with the warmer water below; this is indicated in the following table.

Table XXV

The depth distribution of Cyllopus *spp. as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	8	84	1·9
100–50	5	81	1·2
250–100	5	33	1·0
500–250	9	29	1·9
750–500	0	21	0
1000–750	1	17	0·2

Barnard (1932) has already shown that both species exhibit a migration towards the surface during the night, and our N 100 H results support this. This migration is further described and illustrated on p. 237 and in Fig. 122.

C. magellanicus has previously been taken in the Antarctic by the National Antarctic (Discovery) (Walker, 1907) and Terra Nova (Barnard, 1930) Expeditions, and *C. lucasii* by the latter expedition only.

Amphipoda *alia*. The number of remaining unidentified Amphipods are recorded in the tables in Appendix II.

Isopoda

A few Isopods were taken in the collections as follows:

Munnopsis sp.

St. WS 22 ... 1 at 1000–750 m.
St. WS 26 ... 1 at 750–500 m.
St. WS 69 ... 1 at 1000–750 m.

Rhabdocheirus sp.

St. WS 61 ... 9 at 500–250 m.

Isopoda *alia*.

St. WS 28 ... 1 at 145–100 m.
St. WS 30 ... 1 at 250–100 m.
1 at 500–250 m.
St. WS 67 ... 1 at 1000–300 m.
St. WS 114 ... 1 at 116 m.

Mysidacea

The 'Terra Nova'[1] collected seven species of Mysidacea from South Georgia: *Pseudomma armatum*, *P. sarsii*, *Mysidetes posthon*, *Antarctomysis maxima*, *A. ohlinii*, *Eucopia australis* and *Dactylamblyops antarctica*. The Swedish Antarctic Expedition[2] had already collected *Mysidetes posthon* and the two species of *Antarctomysis*. More recently Rustad (1930*a*) has retaken the first five, all from stations within Cumberland Bay, and with the exception of one station he took them all in the deepest of his series of three, four, or five vertical hauls.

All the specimens collected in the N 100 H nets in the survey round South Georgia, the nearest stations to land being 5 miles off the coast, proved to be of the single species *Antarctomysis maxima*, Holt and Tatt. The specimens of Mysidacea taken in the N 70 V nets, and recorded in Appendix II, have not yet been determined, and it is likely that other species are present in the samples taken near the bottom.

A. maxima was confined to the waters above the continental shelf of South Georgia. During the December-January survey of 1926–7 it was abundant off the south-west coast, being spread over the wide shelf on that side; it was scarce to the north-west and south-east and all but absent from the north-east coast. Thus it had a distribution directly opposite to that of the Euphausiids, particularly that of *Euphausia superba*, as will be seen by comparing Fig. 88 with Fig. 92. This distribution is particularly interesting in relation to the hypothesis of animal exclusion and in relation to this it will be further discussed in a later part on p. 303. A complete record of its occurrence is given in Appendix II. Sometimes, particularly in the hours of darkness, it occurred in large numbers in the mid-water net of the series of three, but only occasionally and in small numbers did it occur at the surface.

Antarctomysis maxima is circumpolar in distribution; it has been taken by the Belgica,[3] Swedish Antarctic,[2] National Antarctic (Discovery),[4] Française,[5] Terra Nova[1] and Aurora[6] Expeditions.

Euphausiacea

The Euphausiacea form a very prominent feature of the plankton of the area and are represented by six species of the genus *Euphausia*, and two species of *Thysanoessa*.

The N 100 H nets proved to be the most efficient nets for sampling the Euphausiacea. Unfortunately, these nets were not used at the four stations approaching South Georgia from the north-east in February 1926. Under the heading of each species we will describe its occurrence in the different regions within the area, omitting reference to the February 1926 line just mentioned unless the species was taken in the N 70 V nets there used.

Euphausia frigida, Hansen. This cold-water form, both in the adult and larval stages, was well represented in our collections round South Georgia. Before discussing its distribution it is necessary to draw attention to the remarkable diurnal vertical migration

[1] Tattersall (1923).
[2] Hansen (1913, 1921).
[3] Hansen (1908).
[4] Tattersall (1908).
[5] Coutière (1906, 1917).
[6] Tattersall (1918).

which it makes. This is discussed more fully on p. 240 and illustrated in Fig. 125. The species appears to rise rapidly into the upper layers of the water at the onset of darkness, and during the hours of daylight it sinks out of range of the series of tow-nets almost altogether—below 150 or 200 m. This phenomenon, which appears all the more remarkable when we consider the physical and chemical changes met with in the water, makes the study of its distribution very difficult, for to get comparable results all our observations should be made during the hours of darkness. A comparison between Fig. 90, showing its distribution as revealed by our nets, and Fig. 89, showing the stations taken in the hours of darkness, will make this clear. We might be inclined to say that it occurred in the largest numbers over the edge of and just beyond the Continental Shelf were not the outermost observations usually taken at night. Since it occurred in comparatively small numbers at the night stations taken on the lines to the west, south-west and south we may conclude that like *E. superba* it is more abundant off the north-east coast. The distribution of these two species will be further considered in a later part in relation to the principle of animal exclusion. The species, like *E. superba*, also exhibits a patchiness

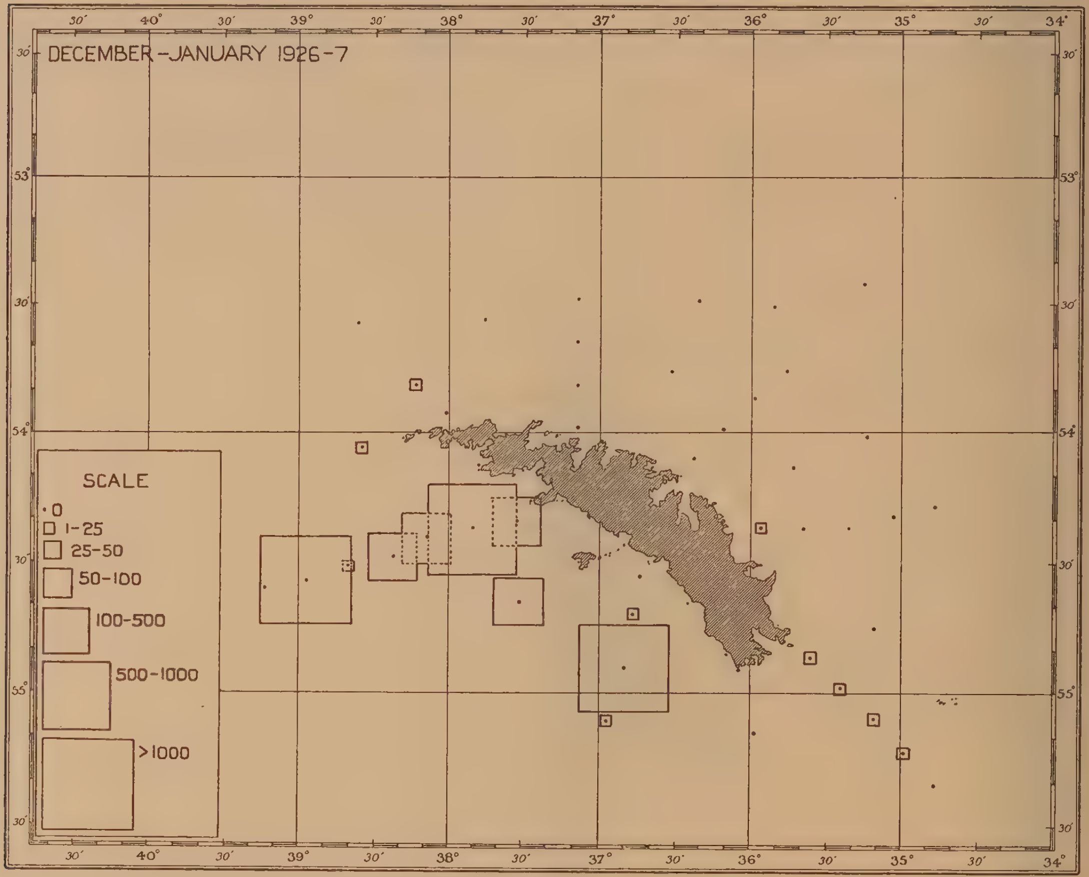

Fig. 88. Chart showing the distribution of *Antarctomysis maxima* at stations in the South Georgia December–January 1926–7 survey. The squares represent the numbers taken in three N 100 H nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively.

in distribution, although, as far as our observations go, to nothing like the same degree. This patchiness is described on p. 256 and illustrated in Fig. 131. Owing to its diurnal migration it is impossible to compare the November and May lines with those of December and March, and so come to a conclusion regarding its seasonal fluctuations.

We should not expect this species to be present in the warmer waters of the sub-Antarctic Zone, and it was absent, except curiously enough for a single specimen taken in an N 100 H net at a depth of 146 m. at St. WS 70 far across the line of Antarctic Convergence. The temperature at this depth was 4·35° C. and the salinity 34·16 °/₀₀.

A complete record of the occurrence of adult and larval forms is given in Appendix II. The distribution of larval forms as revealed by the N 70 V nets is shown in Fig. 91. No larvae were taken on the oceanic line approaching South Georgia from the north-east in February 1926. In November only calyptopis and furcilia stages were taken, whereas in May only one furcilia was taken all the rest being cyrtopia. Calyptopis stages were never abundant. In the December-January survey larvae were almost equally abundant on each side of the island.

The proportions of the different stages taken at different seasons round South Georgia may be summarized as follows:

	Calyptopis %	Furcilia %	Cyrtopia %
November	3·8	**96·2**	0
December	1·3	**53·8**	44·9
January	0·9	5·0	**94·1**
March	3·6	2·6	**93·8**
May	0	1·1	**98·9**

It should be remembered that the January samples were nearly all taken to the west and south-west of the island (see Fig. 37) whereas those of all other seasons are confined to the north-east and south-east side of the island.

The distribution in depth of the adult and larval stages is given in the following tables, in which the hauls are divided into day and night hauls. Here there is further evidence of the vertical migration of the species, showing the centre of abundance for the adult in the daytime to be between 250 and 500 m. and at night between 50 and 100 m.; and for larval forms between 100 and 250 m. in daytime and 50 and 100 m. at night. The question of the reality of this vertical migration is more fully discussed in the special section on p. 244.

Tattersall (1924) in his report on the Euphausiacea collected by the British Antarctic (Terra Nova) Expedition states that, except for the record by Zimmer (1914) of fourteen specimens collected by the German South Polar (Gauss) Expedition in 58° 29′ S, all the specimens up to then recorded were taken from within the isotherm 12° C. and outside the limits of pack-ice. Recently Rustad (1930*b*) and Ruud (1932) on the Norvegia and Vikingen Expeditions obtained specimens between Bouvet Island and South Georgia, the latter obtaining odd specimens at four stations between 61° 23′ and 61° 37′ S. During

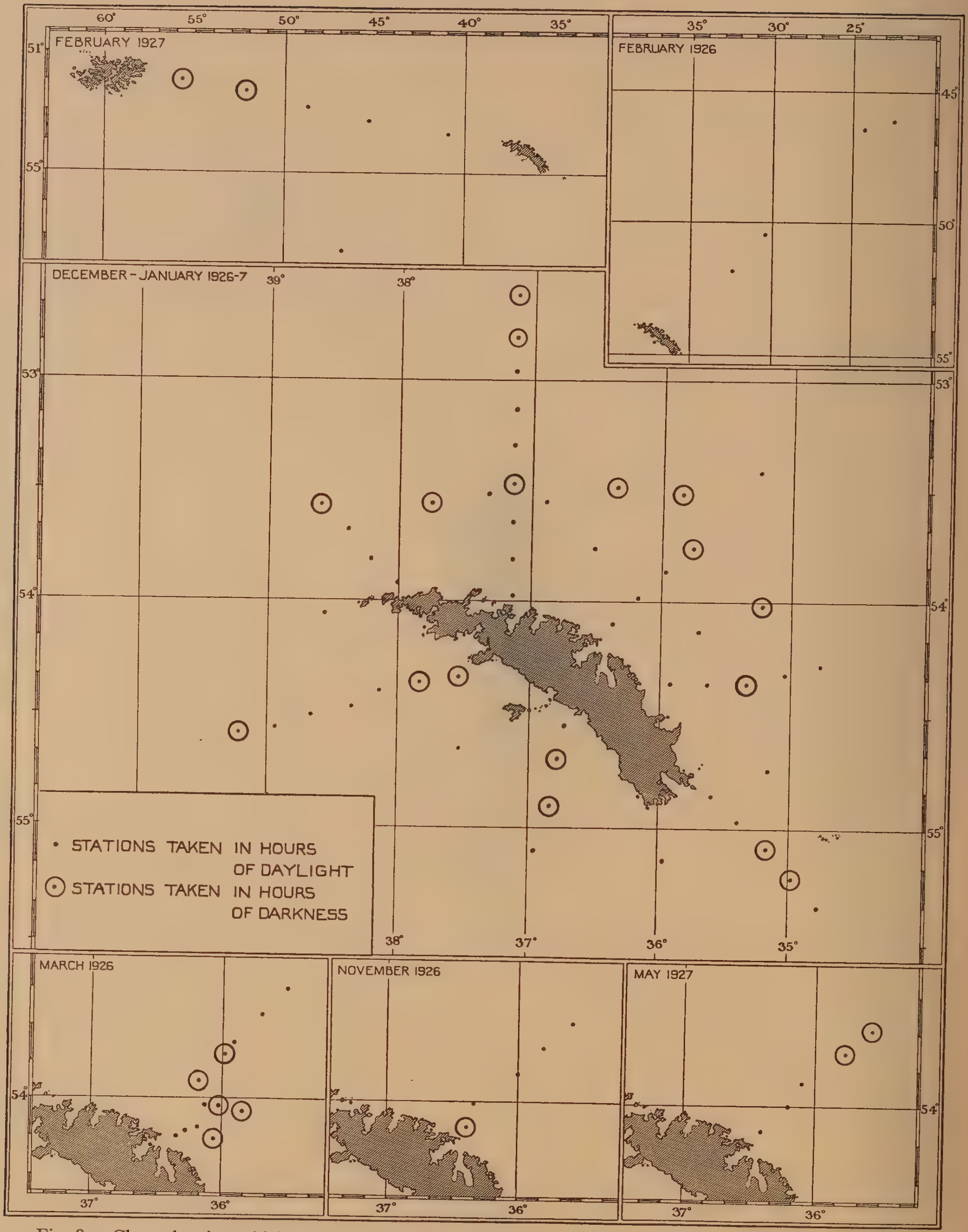
FEBRUARY 1927
FEBRUARY 1926
DECEMBER - JANUARY 1926-7
MARCH 1926
NOVEMBER 1926
MAY 1927
• STATIONS TAKEN IN HOURS OF DAYLIGHT
⊙ STATIONS TAKEN IN HOURS OF DARKNESS
60°
55°
50°
45°
40°
35°
30°
25°
39°
38°
37°
36°
51°
53°
54°
55°
45°
50°

Fig. 89. Chart showing which of the N 100 H net stations were taken in daylight (sunrise to sunset) and which taken in darkness (sunset to sunrise).

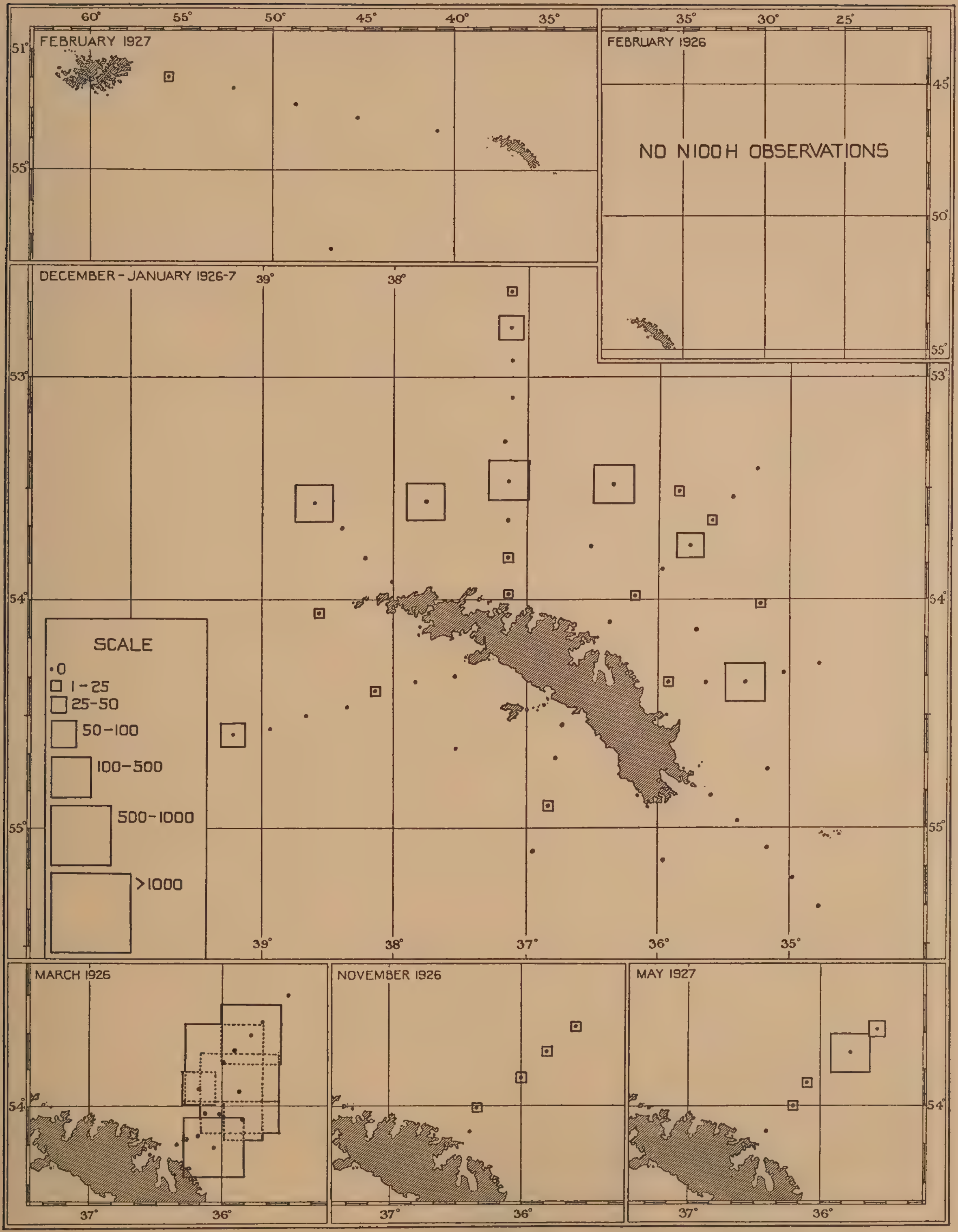
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
NO N100H OBSERVATIONS
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
•0
□ 1-25
25-50
50-100
100-500
500-1000
>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 90. Charts showing the distribution of *Euphausia frigida* at stations in the 1926–7 surveys. The squares represent the numbers taken in three N 100 H nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively. This figure should be compared with Fig. 89 opposite.

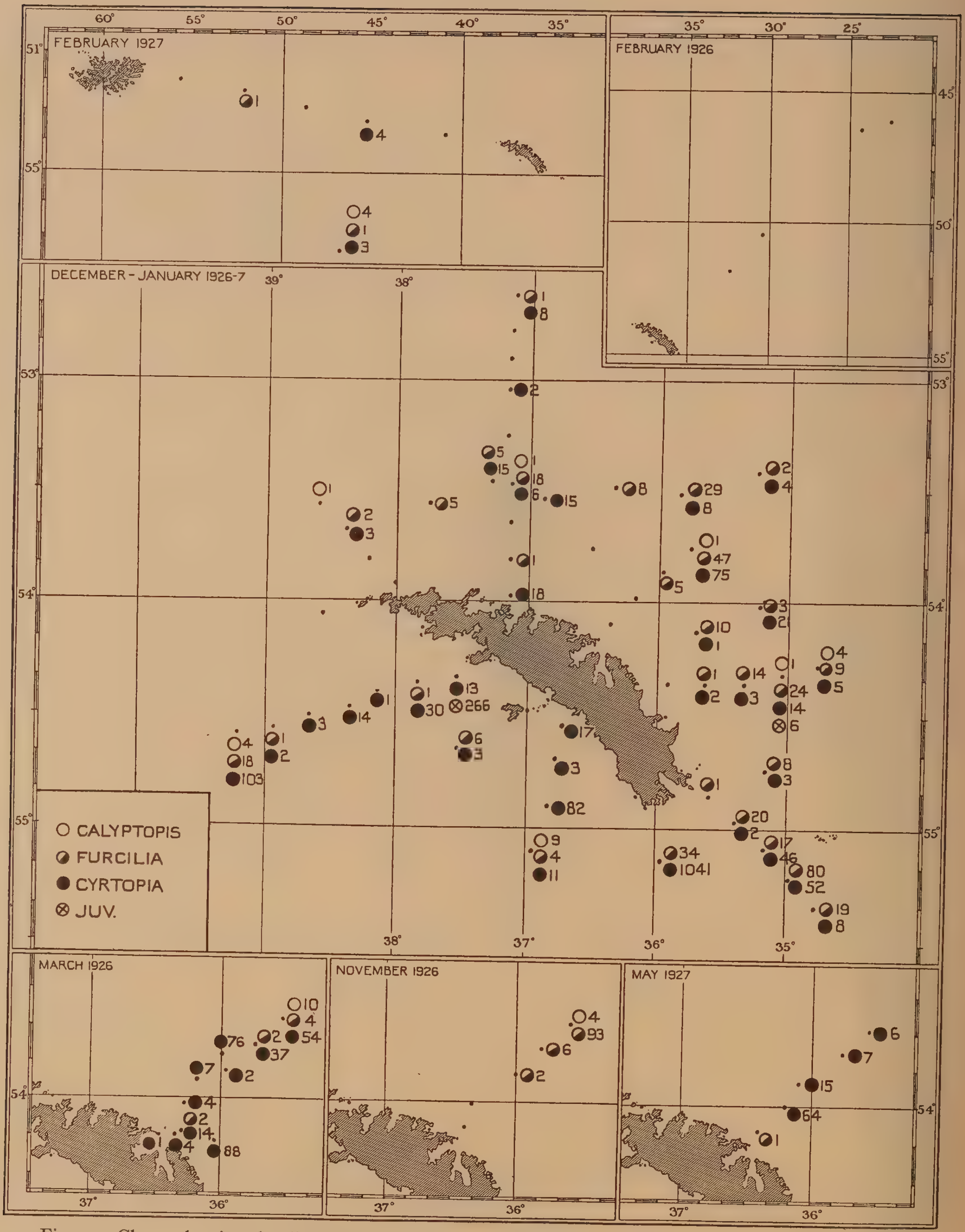
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
1
4
4
1
3
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
DECEMBER - JANUARY 1926-7
39°
38°
53°
54°
55°
1
8
2
5
15
1
18
6
15
8
29
8
2
4
1
2
3
5
1
47
75
1
5
18
3
2
10
1
1
14
1
2
3
24
14
6
4
9
5
1
1
30
13
266
14
3
1
2
4
18
103
6
3
17
3
1
8
3
82
20
2
17
46
80
52
19
8
9
4
11
34
1041
38°
37°
36°
35°
CALYPTOPIS
FURCILIA
CYRTOPIA
JUV.
MARCH 1926
10
4
54
76
2
37
7
2
4
2
14
1
4
88
54°
37°
36°
NOVEMBER 1926
4
93
6
2
37°
36°
MAY 1927
6
7
15
64
1
54°
37°
36°

Fig. 91. Charts showing the distribution of *Euphausia frigida* larvae taken in N 70 V nets in the 1926–7 surveys. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

the present Discovery investigations both on the first commission, outside the area we are at present dealing with, and subsequently, a wealth of material has been collected and an adequate discussion on the distribution of the species must be left for later reports. We may, however, say that the species is a sub-Antarctic and Antarctic form, but not extending into such high latitudes as does *E. superba*. It appears to be circumpolar in its distribution.

The Swedish Antarctic Expedition (Hansen, 1913) took a number of specimens of *E. frigida* from the South Georgia area.

Table XXVI

The depth distribution of Euphausia frigida *as shown by the N 70 V nets*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	0	5	59	25	0	4·0
100–50	1	35	56	25	0·4	28·0
250–100	3	18	18	15	1·1	8·0
500–250	11	1	15	14	3·0	0·3
750–500	1	0	8	13	0·5	0
1000–750	0	7	7	10	0	2·8

Table XXVII

The depth distribution of E. frigida *cyrtopia as shown by the N 70 V nets*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	9	44	59	25	3·0	35·2
100–50	22	55	56	25	7·8	44·0
250–100	51	49	18	15	18·9	21·8
500–250	12	0	15	14	3·2	0
750–500	0	0	8	13	0	0
1000–750	0	7	7	10	0	2·8

Euphausia longirostris, Hansen. This species was only taken at three stations between South Georgia and the Falkland Islands across the line of Antarctic Convergence, see Fig. 94.

St. 46 ... ... 19 at 0–5 m. St. WS 68 ... 1 at 50–0 m. St. WS 69 ... 2 at 50–0 m.

It is a sub-Antarctic species, circumpolar in distribution, having been taken between latitudes 37° 47′ S and 56° 49′ S by the following expeditions: Challenger,[1] Belgica,[2] National Antarctic (Discovery),[3] Gauss,[4] Scotia[5] and Terra Nova.[6]

[1] Sars (1885).
[2] Hansen (1908).
[3] Tattersall (1908).
[4] Zimmer (1914).
[5] Tattersall (1913).
[6] Tattersall (1924).

Euphausia lucens. This species was taken at only one station, St. 47, approaching the Falkland Islands well across the line of Antarctic Convergence (see Fig. 14), where forty-three males and thirty-six females were taken in a surface N 100 H net.

Table XXVIII

The depth distribution of E. frigida *furcilia as shown by the N 70 V nets*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	4	23	59	25	**1·3**	**18·4**
100–50	66	93	56	25	**23·6**	**74·8**
250–100	83	30	18	15	**30·7**	**13·3**
500–250	4	1	15	14	**1·1**	**0·3**
750–500	3	0	8	13	**1·5**	**0**
1000–750	19	0	7	10	**10·9**	**0**

Table XXIX

The depth distribution of E. frigida *calyptopis* as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	15	84	**3·6**
100–50	7	81	**1·7**
250–100	11	33	**2·2**
500–250	0	29	**0**
750–500	0	21	**0**
1000–750	2	17	**0·5**

* The numbers are too small for separate treatment of day and night hauls.

Euphausia superba, Dana. Numerically this species is by far the most important member of the order in this area; indeed, one is tempted to believe that ecologically it is the most important zooplankton organism of the Antarctic. Its importance has been recognized for many years. Hansen (1908) writes that "*E. superba*, established in 1852, seems to live everywhere in the Antarctic Ocean as it has been taken by every expedition touching or exploring any part of those seas". Tattersall (1913) writes that "it is the Euphausian 'par excellence' of the Antarctic Ocean. It is circum-polar in distribution and has been recorded by all the recent expeditions that have visited those waters. It likewise forms the major part of the food of the crab-eating seal (*Lobodon carcinophaga*) and of certain of the penguins". The Australian Antarctic Expedition[1] found it in the stomachs of the Weddell Seal (*Leptonychotes weddelli*) and Emperor Penguin (*Aptenodytes forsteri*). Rustad (1930*b*) writing of his voyage in the

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[1] Tattersall (1918).

'Norvegia' says, "The present species was on the whole the only Euphausiid present in the contents of the stomachs. The contents from the Crab-eater seals (*Lobodon carcinophagus*) in both cases weighed about 2 kg. and consisted almost entirely of Euphausiids. The contents from the Sea-leopard (*Stenorhynchus leptonyx*) weighed about 5 kg., but here the Euphausiids bear but a small proportion to the rest of the contents".

Clark (1919), in describing the biological observations of the Endurance Expedition, writes as follows:

> ...During the winter spent at Elephant Island, our total catch of gentoo penguins amounted to 1436 for the period April 15 to August 30, 1916. All these birds were cut up, the livers and hearts were extracted for food, and the skins were used as fuel. At the same time the stomachs were invariably examined, and a record kept of the contents. The largest proportion of these contained the small crustacean *Euphausia*, and this generally to the exclusion of other forms. Occasionally, however, small fish were recorded. The quantity of *Euphausiae* present in most of the stomachs was enormous for the size of the birds.... *Euphausiae*, then, seem to be present in sufficient quantity in certain, if not in all, sub-Antarctic waters during the southern winter....

Different expeditions have found it in a number of bird stomachs, and the South Georgian whalers are familiar with the enormous congregations of Nototheniid fish which collect to feed upon the swarms of this Euphausian on the whaling grounds. But of particular importance—economic importance—is the fact established by Mackintosh and Wheeler (1929) that this species, *Euphausia superba*, forms practically the sole food of the great rorquals—the Blue and Fin whales—in this area. Racovitza (1903) had already drawn attention to its importance as the food of the Humpback whale. Mackintosh and Wheeler examined the stomach contents of 519 Blue and Fin whales at the whaling station at Grytviken, South Georgia, and found all but 68 to contain food and usually in large quantities. This food consisted entirely of *E. superba*. They write as follows:

> ...The whales caught at South Georgia (excluding the Sperm whale) feed exclusively on *Euphausia superba* (Fig. 100) and have no other food whatever in their stomachs apart from a few specimens of the Amphipod *Euthemisto*, which is so abundant in the plankton round South Georgia that the whales can hardly help swallowing a certain quantity.... The enormous abundance of the krill round South Georgia is revealed by an examination of the stomach contents of the whales caught there. Normally the stomach was found to be well filled with comparatively fresh Euphausiids and an empty stomach was at most times an uncommon occurrence.

Clark (1919) had previously examined Fin, Blue and Humpback whales at South Georgia and found that they all (number not stated) contained *Euphausia* with a mixture of Amphipods.

Ruud (1932) brings confirmation of these observations from the results of his stomach investigations on board the floating factory ship 'Vikingen' working in an area between Bouvet Island and the South Orkneys. He writes:

> In the season 1929–30 the whaling boats of the S.S. 'Vikingen' caught 865 whales. Of the animals we were able to examine (about 300), only a couple had empty stomachs, and these were young whales with traces of milk in the stomach and intestine. All the others had krill in their stomachs,

> usually in large quantities. Occasionally we found a fish or two among the krill; apart from this we did not find anything but *Euphausia superba*.
>
> It will be seen from the chart of our positions that the bulk of our catch was made far from land and known banks, but always in close proximity to the pack-ice. Our whalers always tried to follow the drifting ice, partly in order to be in water which was calm enough for handling the carcases, and partly because the blue whale prefers to frequent the edge of the ice or even the larger lanes between the pack-ice. Evidently, therefore, there must be great quantities of krill out at sea among the icebergs and drifting floes, and not chiefly near land and coastal banks as suggested by Mackintosh and Wheeler....

E. superba, as will shortly be described, occurred abundantly off the north-east coast of South Georgia, both in March 1926 and in December and January 1926–7. The relation of its distribution to that of the whale fishery at the time of our surveys is discussed in a special section on p. 273. That it is not evenly distributed through the water is clearly shown by the two series of consecutive net hauls which were taken off the north-east coast of South Georgia in January, 1927. These are described on p. 254 and illustrated in Fig. 134. It is seen to occur in dense patches, not more than half a mile across and in all probability less than 200 yards across, and patches which are fairly evenly separated from one another by gaps of over half a mile. This concentration of the Euphausians into small densely crowded areas helps one to understand how the large rorquals are able to collect sufficient to form an ample meal. Mackintosh and Wheeler (1929) make an interesting observation in this connection in commenting on the krill found in the stomachs during the 1926–7 season. They state that:

> ...The krill differed from that of other seasons in the fact that there was in most cases a noticeable mixing of Euphausiids of different sizes. These were not always mixed indiscriminately in the stomach. Large or small individuals might be found together in different parts of the mass of stomach contents, or patches of large ones might occur in a mass of smaller forms, suggesting that the whale had been feeding on separate shoals which differed in respect of the sizes of the individuals....

On more than one occasion we saw a dense swarm of young *E. superba* in Cumberland Bay, South Georgia. We will quote from a journal written (by A.C.H.) at the time:

> ...For a whole day there was a dense swarm, like a red cloud, of closely-packed Euphausians (*Euphausia superba*) against the jetty at our shore station. There must have been thousands and thousands in a close swarm some four feet across. They were all swimming hard and going round and round, sometimes in a circular course, sometimes in a 'figure 8', but never breaking away from the one mass. The cloud would sometimes change shape, elongate this way or that. (There appeared to be some guiding 'principle'—almost as if there was some leader in command of the whole!) At times they would form into two such moving parties and one would tend to separate from the other, so that the swarm became dumb-bell shaped; but as soon as the connecting link became of a certain thinness the one part would turn back and flow into the other to form one big swarm again. It was drawn into the whole like the pseudopodium of an amoeba; indeed the whole swarm appeared to behave as one large organism. It was for the most part at the surface, but at times the whole would sink down almost out of sight to rise again. This would happen apparently spontaneously, or again happen if some sudden disturbance occurred, the approach of a boat for instance. They were so close to the pier, at times even below it, that one could look straight down on to them and observe them with ease. I put in my walking stick and stirred the whole swarm up quickly so as to scatter them in all directions; but within half a minute they were all back again in their old formation.

> Other swarms were recorded by fishing parties out by the kelp at the entrance of the harbour and on another day we had a similar swarm close to the ship in mid-harbour, just a few hundred yards from the whaling station itself. They were half-grown specimens just developing their reproductive organs....

It may be mentioned that farther to the south in the Bransfield Strait—not included in the present report—we obtained abundant evidence from a series of consecutive net hauls of the patchiness of very young *E. superba*.

Whilst a vertical diurnal migration of this species is not so well marked as in *E. frigida* or *E. triacantha*, there is nevertheless evidence that such a migration frequently although not invariably takes place. This is fully discussed in the special section dealing with vertical migration on p. 237 and illustrated in Fig. 127. Unlike the other two species, which may sink almost entirely out of range of the N 100 H nets, *E. superba* is more confined to the upper cold water layer, i.e. between the surface and 200 m. Thus the effect of night stations on our knowledge of its distribution is not so marked as it was in the case of the other two species. Its range of depth may be to some extent gauged by the results of the N 70 V nets, although these nets only occasionally capture the species and in small numbers. Except for two occasions, to be mentioned later, at stations across the line of Antarctic Convergence, it was never taken in the N 70 V nets below 100 m.—but 19 specimens were taken in the nets from 50–0 m. and eight in the nets from 100–50.

We will now describe the distribution of *E. superba* at the different seasons and regions within the survey. As already explained the N 100 H nets were not used at the oceanic stations approaching South Georgia from the north-east in February 1926, so that we cannot gauge its occurrence on this line; but we know of its presence at any rate in small numbers from four specimens taken with the N 70 V net at St. 11 at a depth of 500–250 m. This was in the cold layer which had dipped below the warm sub-Antarctic surface water. The temperature at 250 m. was 1·08° C. and at 500 m. 2·02° C.

Off the north-east coast in March and April 1926 the N 100 H nets were towed for three miles on each occasion, so that the effect of patchiness was more likely to be eliminated than in the later stations of the survey when the nets were only towed for 1 mile. But by towing for even 1 mile we see by reference to the consecutive net series described on p. 254 that one is more likely to strike a patch than not, and three nets were always towed at three different levels. The *E. superba* was particularly abundant at a distance of some 20 miles from the coast, and absent from or present in small numbers at the outlying stations. This is shown in Fig. 92.

In the same region in November 1926 it was only taken in small numbers.

In the December-January Survey 1926–7 it occurred again in enormous numbers off the north-east coast particularly—in contrast to the preceding March—over the edge of the continental shelf, as many as 42,500 being taken at one station. At those stations taken to the north and east it was present at every station but two, whilst to the west, south and south-east, in marked contrast, it was taken at only five out of nineteen stations and at none of these five stations was it really abundant (Fig. 92). This distribution will be further discussed in relation to the principle of animal exclusion in a later part.

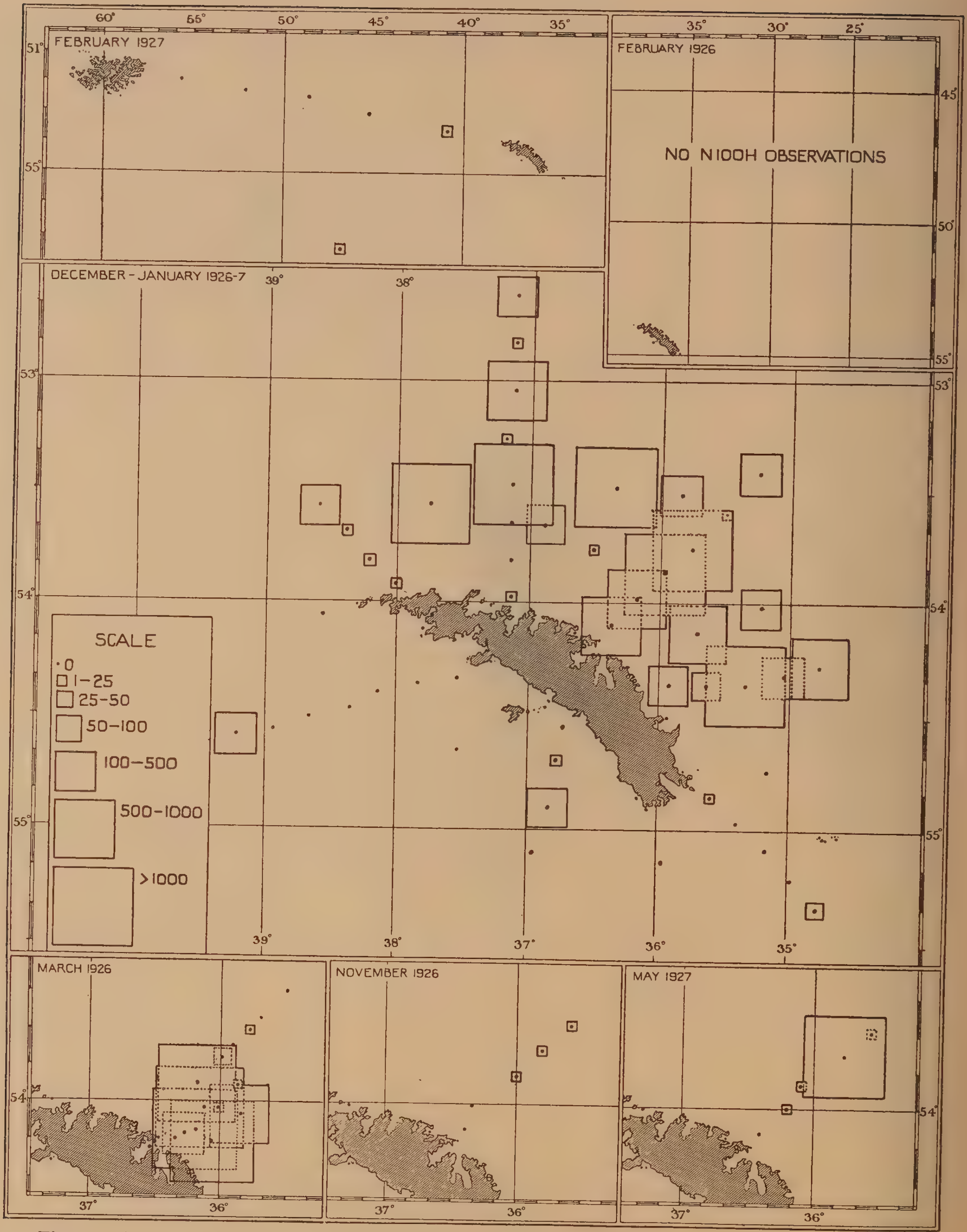
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
NO N100H OBSERVATIONS
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
· 0
1–25
25–50
50–100
100–500
500–1000
>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 92. Charts showing the distribution of *Euphausia superba* at stations in the 1926–7 surveys. The squares represent the numbers taken in three N 100 H nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

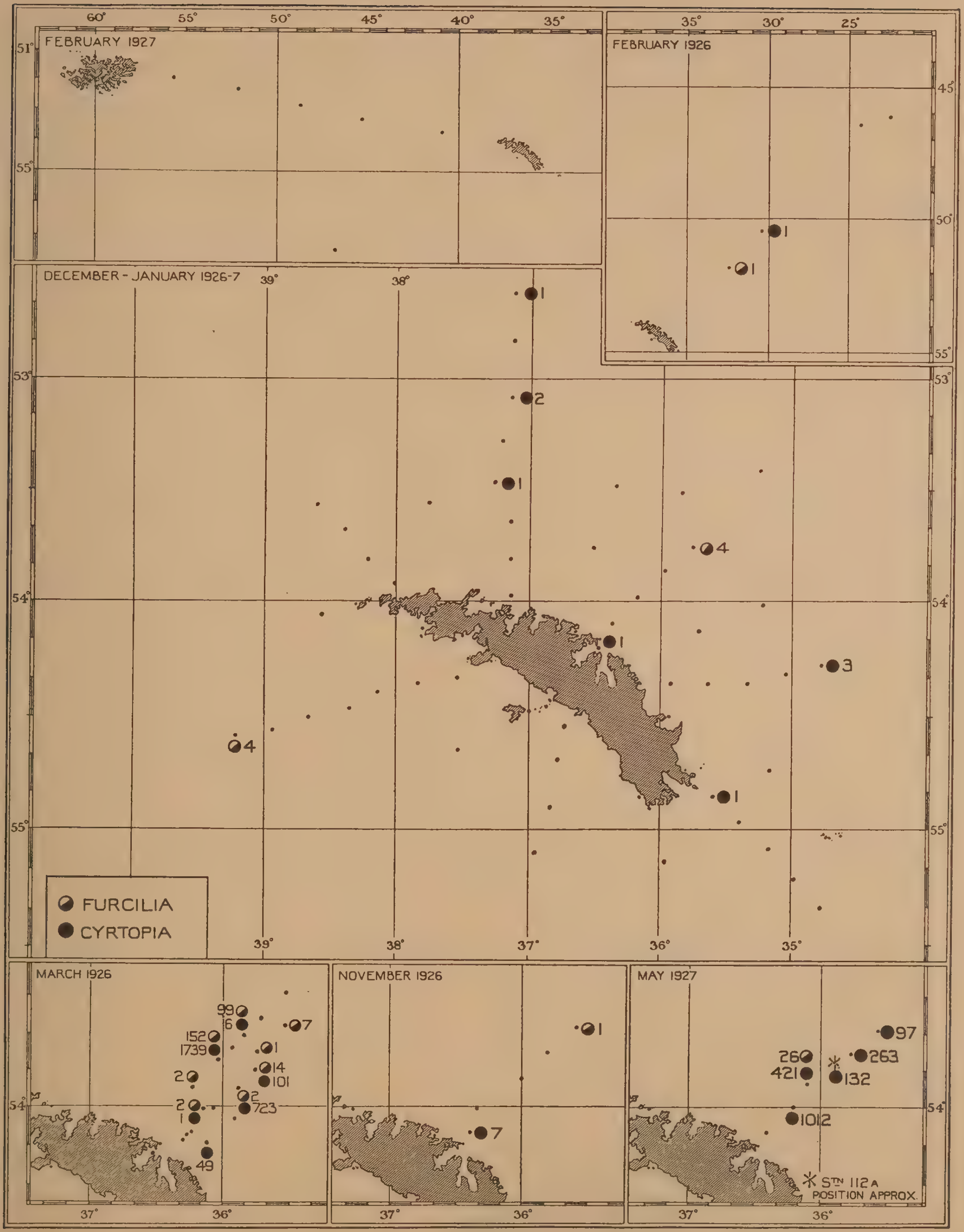
FEBRUARY 1927
60° 55° 50° 45° 40° 35°
51° 55°
FEBRUARY 1926
35° 30° 25°
45° 50° 55°
1
1
DECEMBER - JANUARY 1926-7
39° 38° 37° 36° 35°
53° 54° 55°
1
2
1
4
1
3
4
1
FURCILIA
CYRTOPIA
MARCH 1926
99
6
7
152
1739
1
2
14
101
2
2
1
723
49
37° 36°
54°
NOVEMBER 1926
1
7
37° 36°
MAY 1927
97
26
263
421
132
1012
STN 112A POSITION APPROX.
37° 36°
54°

Fig. 93. Charts showing the distribution of *Euphausia superba* larvae taken in N 70 V nets in the 1926–7 surveys.

In May 1927 it was again abundant over the edge of the Continental Shelf to the north-east of the island.

Between South Georgia and the Falkland Islands, in February 1927, two specimens were taken at St. 160, the station nearest South Georgia on the oceanic line, and then curiously a single specimen was taken at St. WS 70 (250–100 m.) far across the Antarctic Convergence at the same depth as the specimen of *E. frigida* was taken (see p. 203). The temperature and salinity were as follows: 5·01° C., 34·16 $^{\circ}/_{\circ\circ}$ at 100 m. and 4·07° C., 34·19 $^{\circ}/_{\circ\circ}$ at 300 m.

A complete record of the occurrence of *E. superba* is given in Appendix II.

The distribution of the larval[1] stages is shown in Fig. 93.

The depth distribution of larval stages as shown by the N 70 V nets may be tabulated for cyrtopia and furcilia as follows. The numbers are too small to give more than a mere indication that the larvae like the adults belong to the upper layers.

Table XXX

The depth distribution of E. superba *cyrtopia and furcilia as shown by the N 70 V nets*

Depth m.	Total number at each depth		Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth	
	Cyrtopia	Furcilia		Cyrtopia	Furcilia
50–0	66	7	84	15·7	1·7
100–50	67	1	81	16·5	0·25
250–100	0	2	33	0	0·4
500–250	0	1	29	0	0·1
750–500	5	0	21	0·95	0
1000–750	0	0	17	0	0

Of more interest is the seasonal distribution of the larvae which may be tabulated as follows, the figures given being the actual total numbers taken at stations in nets of any kind:

	Furcilia	Cyrtopia
November. South Georgia (1926)	1	7
December. ,, (1926)	2	3, 1, 1
January. ,, (1927)	4	2, 1, 1
February. Oceanic Stations (1926–7)	1	1
March and April. South Georgia (1926)	152, 99, 14, 7, 2, 2, 2, 1	1739, 723, 101, 49, 6, 1
May. ,, (1927)	26	1012, 421, 263, 132, 97

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[1] Identification of the larval stages of closely allied species of southern Euphausiidae has been attended by various difficulties, one of which is the extent of variation that is shown by individuals of one species at similar stages of development, and another is the scanty attention that this subject has hitherto received. Examples of different larvae have been submitted to Mr F. C. Fraser, who is preparing a monograph upon the development of *E. superba*; he has kindly examined them and confirmed our identifications.

Percentages have not been worked out as in the case of *E. frigida* because there is an obvious indication of a tendency to occur in swarms, and the large numbers taken when this is so might give quite a false idea of the relative proportions of the different stages when we have such a limited number of occurrences to consider. The figures give some indication of the course of development during the season and should be compared with the observations made by Ruud (1932) on the earlier stages, calyptopis and first furcilia, in December and January farther to the south. It would seem likely that the larvae are spawned farther to the south, and are carried northwards by the cold polar layer as they develop. Ruud took enormous numbers of calyptopis stages, particularly stages 1 and 2, in his nets used at his two stations Nos. 11 and 12, which were situated almost due south of South Georgia in latitudes 61° 42′ S and 61° 37′ S respectively.

Ruud (1932) and Wheeler[1] independently, by the measurement of *E. superba* taken in whale stomachs, have shown the presence of two size-groups, indicating that the species takes two years to come to maturity.

Since the present survey was made a vast amount of *E. superba* material, both larval and adult, has been collected during the Discovery investigations, and more detailed reports are in preparation by other workers, so that no further discussion will be given here upon the many interesting problems raised by this species—problems which can only be solved by the consideration of large quantities of material.

Euphausia triacantha, Holt and Tattersall. This species was at times moderately abundant off the north-east and north coast of South Georgia, and between this island and the Falkland Islands. It occurred at only one station off the south coast and was absent from the south-west and west of the island—except for a single specimen taken at St. 161 far to the south-west at a depth of 500–250 m.—below the cold surface layer. The following is a statement of its occurrence:

Approaching South Georgia from the north-east, February 1926:

St. 11	(N 70 V)	8 at 500–250 m.

North-east coast, March-April 1926:

St. 17	(N 70 V)	1 at 500–250 m.
St. 26	(N 100 H)	61 at 60–0 m.
St. 31	(N 100 H)	30 at 100–0 m.
	(N 70 V)	2 at 220–100 m.
St. 37	(N 100 H)	153 at 50–0 m.
		71 at 90–0 m.
St. 41*a*	(N 70 V)	2 at 265–150 m.
St. 41*b*	(N 70 V)	2 at 265–150 m.
St. 41*c*	(N 70 V)	1 at 240–150 m.
St. 41*d*	(N 70 V)	1 at 250–100 m.
St. 44	(N 100 H)	26 at 55–0 m.
		24 at 110–0 m.
		4 at 170–0 m.

North-east coast, November 1926:

St. WS 20	(N 70 V)	1 at 500–250 m.
St. WS 22	(N 70 V)	1 at 750–500 m.
		2 at 1000–750 m.

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[1] Not yet published but contained in report to the Discovery Committee 1930.

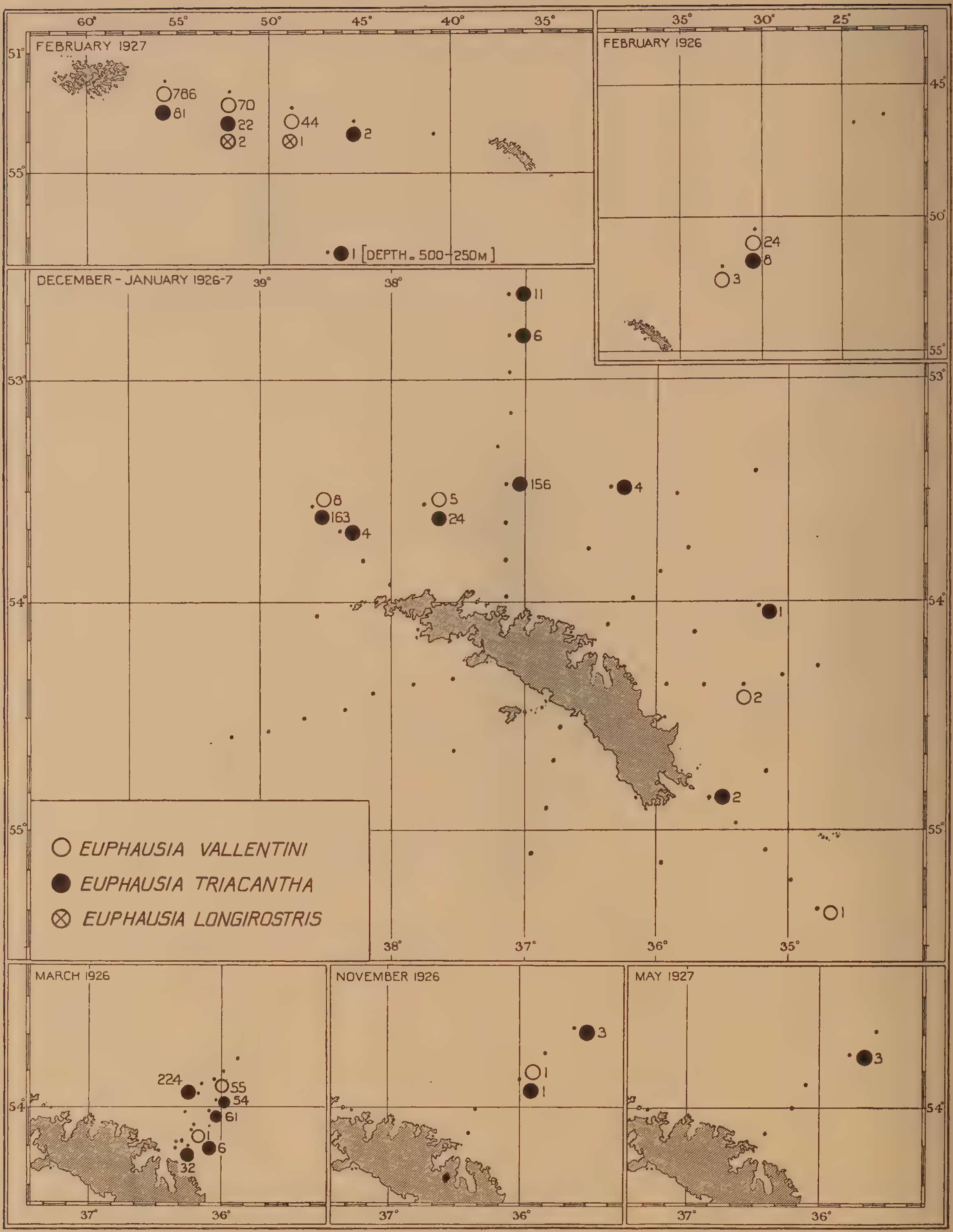
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
786
81
70
22
2
44
1
2
1 [DEPTH = 500–250M]
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
24
8
3
DECEMBER – JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
11
6
156
4
8
163
4
5
24
1
2
2
1
EUPHAUSIA VALLENTINI
EUPHAUSIA TRIACANTHA
EUPHAUSIA LONGIROSTRIS
MARCH 1926
224
55
54
61
1
6
32
NOVEMBER 1926
3
1
1
MAY 1927
3

Fig. 94. Charts showing distribution of *Euphausia vallentini*, *E. triacantha* and *E. longirostris* taken by all nets in the 1926–7 surveys. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

December-January survey round South Georgia, 1926–7:

St. 125	(N 100 H)	2 at 140 m.
	(N 70 V)	2 at 500–250 m.
St. 129	(N 100 H)	156 at 80–0 m.
St. WS 26	(N 100 H)	18 at 96 m.
	(N 70 V)	4 at 500–250 m.
		2 at 750–0 m.
St. WS 29	(N 70 V)	4 at 500–250 m.
St. WS 30	(N 100 H)	160 at 134 m.
	(N 70 V)	2 at 500–250 m.
		1 at 750–500 m.
St. WS 31	(N 100 H)	2 at 53 m.
St. WS 38	(N 70 V)	1 at 500–250 m.
St. WS 60	(N 100 H)	6 at 146 m.
St. WS 61	(N 100 H)	11 at 132 m.

North-east coast, May 1927:

St. WS 110 (N 70 V) 3 at 1000–750 m.

Between South Georgia and the Falkland Islands:

St. 161	(N 70 V)	1 at 500–250 m.
St. WS 67	(N 70 V)	2 at 1000–300 m.
St. WS 69	(N 100 H)	19 at 146 m.
St. WS 69	(N 70 V)	2 at 250–100 m.
		1 at 750–500 m.
St. WS 70	(N 100 H)	81 at 146 m.

This distribution is shown in Fig. 94.

Specimens of *E. triacantha* have been taken by the Valdivia,[1] National Antarctic (Discovery),[2] Swedish Antarctic,[3] Gauss,[4] Norvegia[5] and Vikingen[6] Expeditions, but rarely in large numbers. It appears to have a distribution very similar to that of *E. frigida*, i.e. being sub-Antarctic but extending into the Antarctic Zone although not so far south as *E. superba*.

From our observations it is seen that it often occurs below 250 m., and on one occasion two specimens were taken below 750 m., but also it may occur in quite large numbers in the cold surface layer but *at night*. This vertical migration is discussed and described on p. 240. Our observations confirm Ruud in believing that it does not penetrate quite so far south as *E. frigida*, all the large samples occurring in the north of the region.

Euphausia vallentini, Stebbing. This species is characteristic of the warmer waters of the sub-Antarctic Zone rather than those of the Antarctic Zone and was taken on the oceanic lines towards and across the line of Antarctic Convergence; nevertheless, it occurred at a few stations off the coast of South Georgia in November, December and March.

From Tristan da Cunha to South Georgia, February 1926:

St. 8	(N 100 H)	17 at 0–10 m.
St. 11	(N 70 V)	2 at 50–0 m.
		9 at 100–50 m.
St. 11	(N 70 V)	13 at 500–250 m.
St. 12	(N 70 V)	3 at 500–250 m.

South Georgia, March 1926:

St. 36	(N 100 H)	51 at 50(–0) m.
		4 at 90(–0) m.
St. 41*d*	(N 70 V)	1 at 100–50 m.

South Georgia, November 1926:

St. WS 20 (N 100 H) 1 at 190 m.

South Georgia, December 1926:

St. 136	(N 100 H)	1 at 0–5 m.
	(N 70 V)	1 at 50–0 m.
St. WS 26	(N 100 H)	5 at 192 m.
St. WS 30	(N 100 H)	4 at 67 m.
		4 at 134 m.
St. WS 36	(N 70 V)	1 at 500–250 m.

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[1] Illig (1930). [2] Tattersall (1908). [3] Hansen (1913). [4] Zimmer (1914). [5] Rustad (1930*b*). [6] Ruud (1932).

Towards the Falkland Islands, April 1926 and February 1927:

St. 46	(N 100 H)	38 at	0–5 m.
St. 47	(N 100 H)	104 at	0–5 m.
St. WS 68	(N 70 V)	18 at	50–0 m.
		26 at	100–50 m.
St. WS 69	(N 70 V)	3 at	100–50 m.
	(N 100 H)	30 at	146 m.
	(N 70 V)	7 at	250–100 m.
		7 at	500–250 m.
		22 at	750–500 m.
		1 at	1000–750 m.
St. WS 70	(N 100 H)	19 at	0–5 m.
	(N 70 V)	215 at	50–0 m.
	(N 100 H)	9 at	93 m.
	(N 70 V)	75 at	100–50 m.
	(N 100 H)	451 at	146 m.
	(N 70 V)	16 at	250–100 m.
		1 at	500–250 m.

This distribution is shown in Fig. 94.

The species has been recorded between the latitudes of 32° 15′ S and 58° 29′ S by the Challenger,[1] Belgica,[2] National Antarctic (Discovery),[3] Swedish Antarctic,[4] Gauss[5] and Terra Nova[6] Expeditions.

Rustad (1930*b*) sums up its distribution as follows:

> ...Practically all the larval stages and young specimens and the greater part of the adult specimens from the Swed. Ant. Exp. have been taken at temperatures between + 8° C. and + 10° C. On the other hand, one specimen occurred at about 22° C., and a few specimens at only 1° to 2° C., and a specimen from 58° 29′ S., 89° 58′ E. (Zimmer, 1914) has possibly been captured in a still lower temperature. The main habitat, however, seems to be a circumpolar belt somewhat to the north of the habitat of *E. longirostris*....

At St. WS 20 where a specimen was taken at 190 m. the temperature at 150 m. was − 0·55° C. and at 200 m. + 0·3° C. At St. 136 a specimen was taken at the surface and another between 50 m. and the surface; the temperature at the surface was 1·4° C. and at 50 m. 0·5° C. At St. WS 26 five specimens were taken from water of 0·35° C. and at St. WS 30 four from water of 0·75° C. and four from 134 m. depth when the temperature at 100 m. was − 0·70° C. and at 150 m. − 0·30° C.

It will be seen that in our area *E. vallentini* extends farther south than *E. longirostris*, which was not found south of the line of Antarctic Convergence.

Its range of depth is seen to be from the surface to below 750 m. Out of the eleven stations at which it occurred in the top 100 m. nine were taken during the hours of darkness; this suggests that this species also may exhibit a diurnal vertical migration.

It is perhaps worth drawing attention to the fact that we did not meet with a single specimen of *E. crystallorophias* in this area. This species appears to be confined to higher latitudes than is *E. superba*; it has a circumpolar distribution immediately against the Antarctic Continent and in the vicinity of pack-ice. It was taken by the Belgica,[2] National Antarctic (Discovery),[3] Gauss,[5] Pourquoi-pas?,[7] Terra Nova[6] and Aurora[8] Expeditions, and in more recent Discovery investigations has been met with in large numbers against the ice further south.

[1] Sars (1885).
[2] Hansen (1908).
[3] Tattersall (1908).
[4] Hansen (1913).
[5] Zimmer (1914).
[6] Tattersall (1924).
[7] Coutière (1917).
[8] Tattersall (1918).

Thysanoessa vicina, Hansen, and *T. macrura*, G. O. Sars. The two species were widely distributed in the area, but *T. vicina* was on the whole taken in larger numbers than was *T. macrura*. Specific identification of the males only of the two species was carried out in the analysis of the N 70 V net samples taken throughout the survey, but in the N 100 H samples this identification was only carried out for the first season, March and April, 1926. Identification was often rendered difficult by the mutilation of specimens by the attacks of carnivorous Amphipods taken in large numbers, particularly *Parathemisto*, before the samples were preserved. Thus whilst the N 100 H nets give the better information as to the numbers of *Thysanoessa* present at different stations throughout the survey, the N 70 V nets give us some information regarding the relative abundance of the two species. The results of the N 100 H nets are shown in Fig. 95 and of the N 70 V nets in Fig. 96.

The relative numbers of the two species taken in the N 100 H nets in March and April 1926, will be found in Appendix II, where it will be seen that *T. vicina* is the predominating form. Since all these stations are in a very small area the considerable variation in numbers would suggest that the two species are, like *Euphausia superba*, very patchy in their distribution.

Thysanoessa macrura has been taken from the sub-Antarctic and Antarctic regions by most expeditions: Challenger,[1] Belgica,[2] National Antarctic (Discovery),[3] Swedish Antarctic,[4] Gauss,[5] Scotia,[6] Française,[7] Terra Nova,[8] Aurora,[9] Norvegia[10] and Vikingen[11] Expeditions. All these records are from south of the isotherm of 12° C., except one of the Challenger records from 37° 17′ S and 53° 52′ W. It appears to have a range similar to that of *Euphausia superba*.

Thysanoessa vicina has not been taken so frequently, or in such large numbers, as *T. macrura* by the past expeditions, i.e. only by the National Antarctic (Discovery),[3] the Swedish Antarctic,[4] Gauss,[5] and Terra Nova[8] Expeditions. As pointed out by Tattersall (1924), all the records are between the limit of pack-ice and the isotherm 12° C. Rustad (1930) sums up its distribution by saying, "Altogether the few finds of *T. vicina* indicate a more northern habitat in comparison with *T. macrura*". The results of our survey taken in conjunction with the results obtained by Rustad and Ruud confirm this.

South Georgia is evidently a region where *T. vicina* flourishes, but *T. macrura* is reaching its northern limit, and a little to the south of South Georgia *T. vicina* probably meets its southern limit. Very few *T. macrura* appear on the oceanic line towards the Falkland Islands. At St. 161 far to the south-west of South Georgia no *T. vicina* were recorded and only one *T. macrura*. Turning to the results obtained by Rustad (1930*b*) in the 'Norvegia' and Ruud (1932) in the 'Vikingen' each working to the south or south-east of South Georgia, we find that they met with no *T. vicina* at all, but only *T. macrura*.

There is some indication that the species may undergo a vertical diurnal migration,

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[1] Sars (1885).
[2] Hansen (1908).
[3] Tattersall (1908).
[4] Hansen (1913).
[5] Zimmer (1914).
[6] Tattersall (1913).
[7] Coutière (1906).
[8] Tattersall (1924).
[9] Tattersall (1918).
[10] Rustad (1930*b*).
[11] Ruud (1932).

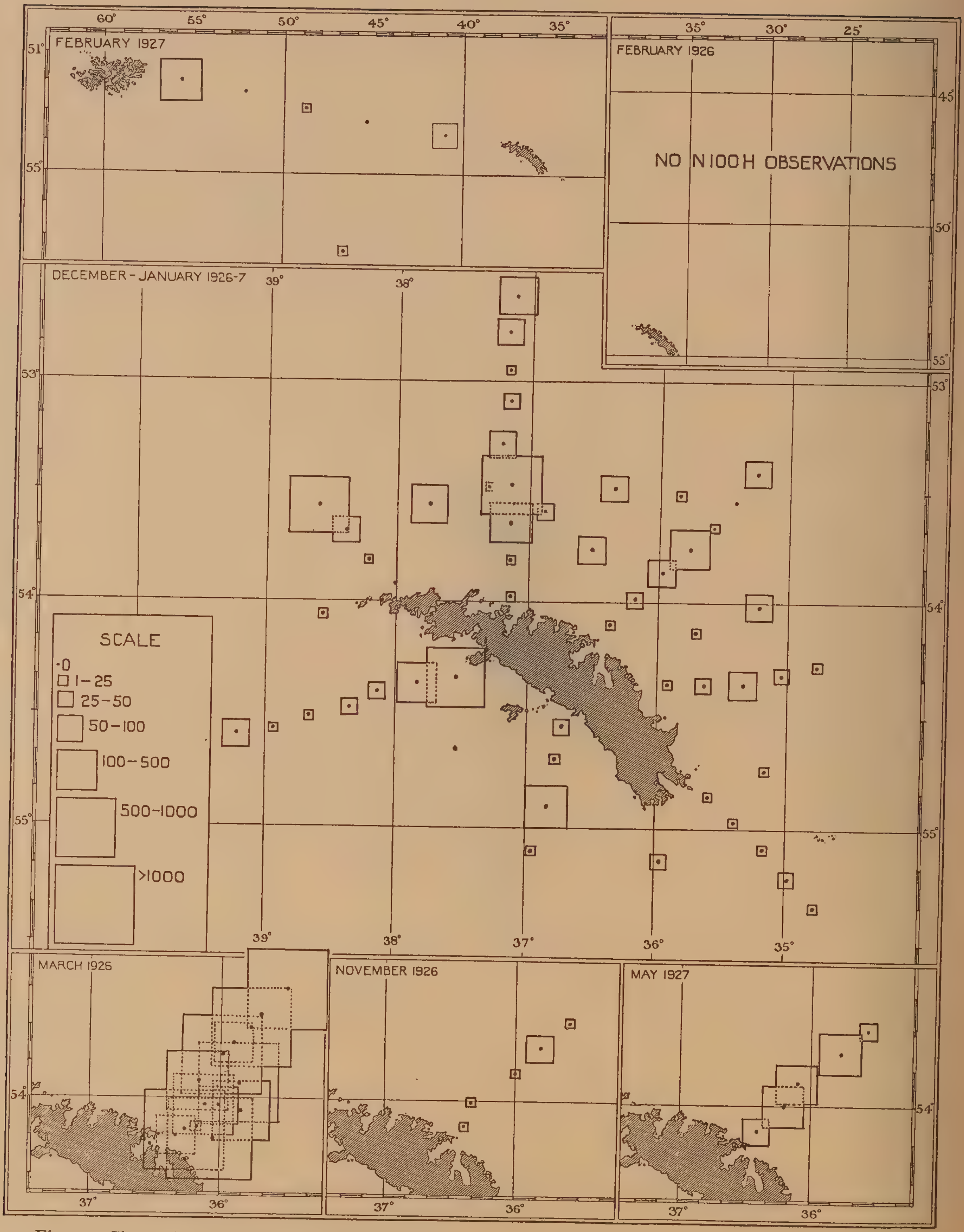
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
NO N 100 H OBSERVATIONS
DECEMBER-JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
·0
□ 1-25
25-50
50-100
100-500
500-1000
>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 95. Charts showing the distribution of *Thysanoessa* spp. at stations in the 1926–7 surveys. The squares represent the numbers taken in three N 100 H nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

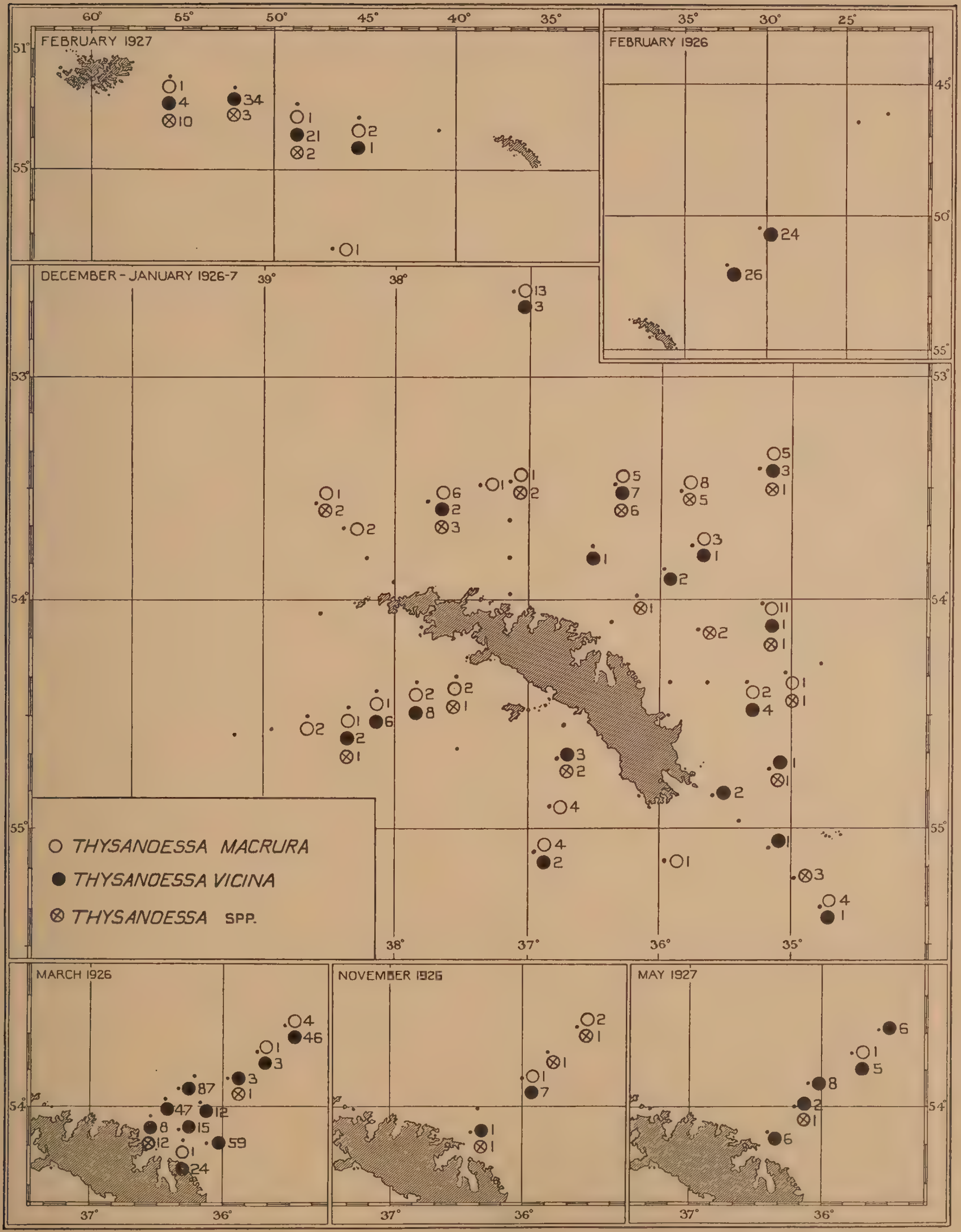
FEBRUARY 1927
FEBRUARY 1926
DECEMBER - JANUARY 1926-7
MARCH 1926
NOVEMBER 1926
MAY 1927
○ THYSANOESSA MACRURA
● THYSANOESSA VICINA
⊗ THYSANOESSA SPP.
60°
55°
50°
45°
40°
35°
30°
25°
51°
55°
45°
50°
53°
54°
39°
38°
37°
36°

Fig. 96. Charts showing distribution of *Thysanoessa* taken in N 70 V nets in the 1926–7 surveys.

but this is not so marked as with the species of *Euphausia*. It is discussed and illustrated on pp. 240 and 255.

The depth distribution may be studied in the following tables. The numbers of *Thysanoessa macrura* males and calyptopis stages were too small to be significant.

Table XXXI

The depth distribution of Thysanoessa vicina, *males, as shown by the N 70 V nets*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	43	70	59	25	**14·6**	**56·0**
100–50	68	77	56	25	**24·3**	**61·5**
250–100	5	17	18	15	**1·8**	**7·6**
500–250	2	4	15	14	**0·5**	**1·1**
750–500	3	0	8	13	**1·5**	**0**
1000–750	0	3	7	10	**0**	**1·2**

Table XXXII

The depth distribution of Thysanoessa *spp., females, as shown by the N 70 V nets*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	47	58	59	25	**15·8**	**46·4**
100–50	66	85	56	25	**23·6**	**68·0**
250–100	23	38	18	15	**8·5**	**16·9**
500–250	7	13	15	14	**1·9**	**3·7**
750–500	7	3	8	13	**3·5**	**0·9**
1000–750	2	3	7	10	**1·1**	**1·2**

Table XXXIII

The depth distribution of Thysanoessa *cyrtopia as shown by the N 70 V nets*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	359	160	59	25	**121·7**	**128**
100–50	266	228	56	25	**95**	**182·4**
250–100	31	66	18	15	**11·5**	**29·3**
500–250	7	1	15	14	**1·9**	**0·3**
750–500	0	6	8	13	**0**	**1·8**
1000–750	0	3	7	10	**0**	**1·2**

Table XXXIV

The depth distribution of Thysanoessa *furcilia as shown by the N 70 V nets*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	291	131	59	25	98·6	104·8
100–50	437	250	56	25	156·1	200
250–100	80	58	18	15	29·6	25·8
500–250	5	0	15	14	1·3	0
750–500	2	0	8	13	1·0	0
1000–750	0	0	7	10	0	0

It is seen clearly that the species belongs to the cold polar layer; these figures should be compared with the charts of temperature and salinity in Figs. 7 and 8. The figures have been divided into those taken in daylight and those in darkness, and in almost every case a striking increase is shown in the night figures for the top 250 m. It has frequently been suggested that the phenomenon of vertical migration is not a real one, and that the results obtained are due to the organisms avoiding capture by the nets during daylight. These figures would at first sight appear to support this, but on being further considered in the special section on vertical migration on pp. 244–250, where we come to the conclusion that this apparent effect is due to the results of both shallow and deep-water stations being here combined together.

The complete record of the occurrence of adult and larval forms is given in the tables in Appendix II.

Decapoda Larvae

Decapod larvae, at present unidentified, were taken at the following stations:

St. 126	9 at 47 m.
St. 127	10 at 41 m.
	20 at 82 m.
St. 128	1 at 100 m.
St. 130	20 at 77 m.
St. 131	3 at 128 m.
St. 133	1 at 100 m.
St. 134	106 at 123 m.
St. 135	4 at 150 m.
St. 138	1 at 155 m.
St. WS 19	2 at 100–0 m.
St. WS 20	1 at 500–250 m.
St. WS 22	2 at 0–5 m.
St. WS 24	4 at 80 m.
	1 at 100–50 m.
	4 at 100 m.
St. WS 28	2 at 80 m.
St. WS 33	12 at 65 m.
	1 at 130–100 m.
St. WS 44	1 at 750–500 m.
St. WS 69	1 at 146 m.
St. WS 70	1 at 146 m.

It is hoped that they will later be reported upon together with other Decapod larvae taken over wider areas by the Discovery investigations.

PTEROPODA

Samples of the different species of Pteropod taken in our collections were sent to the late Miss A. L. Massy, who kindly indentified them for us. She has written a report (1932) upon all the Pteropods taken during the first two years of the Discovery investigations.

Cleodora sulcata (Pfeffer). This species was recorded at only four stations off the north-east coast of South Georgia in March 1926, and at two stations, WS 69 and WS 70, across the line of Antarctic Convergence between South Georgia and the Falkland Islands in February 1927.

St. 12 (N 70 V)	1 at 500–250 m.	St. WS 69 (N 100 H)	8 at 146 m.
St. 36 (N 100 H)	4 at 90–0 m.	St. WS 70 (N 100 H)	13 at 0–5 m.
St. 37 (N 100 H)	27 at 90–0 m.		3 at 146 m.
St. 44 (N 100 H)	1 at 170–0 m.		

It has been taken in the Antarctic by the Belgica,[1] National Antarctic (Discovery),[2] Gauss[3] and Terra Nova[4] Expeditions; the 'Belgica' taking it as far south as 70° 33′ S.

Clione antarctica, E. A. Smith. Taken at a number of stations round South Georgia during the December-January survey in 1926–7 and at stations between South Georgia and the Falkland Islands in February 1927.

It was usually taken near the surface or in the top 100 m., but it was found below 750 m. at St. 151 off the north-east coast of South Georgia and below 500 m. at Sts. WS 68–70 across the Antarctic Convergence, where the surface layer had dipped below the sub-Antarctic surface water. It was not taken off South Georgia in March 1926 or May 1927.

St. 125	20 at 0–5 m.	St. 151	3 at 500–625 m.
St. 126	1 at 23 m.		1 at 1000–750 m.
St. 128	1 at 0–5 m.	St. WS 29	1 at 131 m.
	6 at 50–0 m.	St. WS 37	4 at 80 m.
St. 129	45 at 0–5 m.	St. WS 38	1 at 53 m.
St. 130	11 at 0–5 m.	St. WS 40	16 at 72 m.
	1 at 38 m.	St. WS 43	352 at 0–5 m.
St. 131	18 at 0–5 m.	St. WS 46	4 at 0–5 m.
St. 132	2 at 70–0 m.	St. WS 48	1 at 192 m.
St. 133	12 at 0–5 m.	St. WS 68	2 at 750–500 m.
St. 135	1 at 75 m.	St. WS 69	2 at 250–100 m.
St. 137	12 at 66 m.		3 at 750–500 m.
St. 138	6 at 77 m.	St. WS 70	1 at 750–500 m.
St. 139	5 at 0–5 m.		
	2 at 90 m.		

The species is a true Antarctic form, and has been taken in the far south by the Southern Cross,[5] National Antarctic (Discovery),[2] Gauss,[3] Terra Nova[4] and Aurora[6] Expeditions.

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[1] Pelseneer (1903).
[2] Eliot (1907).
[3] Meisenheimer (1905).
[4] Massy (1920).
[5] Smith (1902).
[6] Hedley (1916).

Limacina balea, Möller. This species was widely distributed throughout the area, but was never abundant, although it occurred in fair numbers at stations between South Georgia and the Falkland Islands—Sts. WS 63, WS 67, WS 68 and WS 69, and in larger numbers off the north-east coast of South Georgia in late May 1927, Sts. WS 110–114. Our knowledge of its depth distribution may be summarized in the following table:

Table XXXV

The depth distribution of Limacina balea *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	331	84	78·8
100–50	456	81	112·6
250–100	38	33	7·7
500–250	53	29	7·3
750–500	22	21	4·2
1000–750	2	17	0·5

A complete record of its occurrence is given in Appendix II.

The species does not appear to have been recorded in the Antarctic Zone before, although the 'Terra Nova'[1] collected specimens in the region of New Zealand.

Limacina helicina (Phipps). This species was taken in larger numbers than any other Pteropod, although it was absent from the line approaching South Georgia from the north-east in February 1926, and absent off that side of South Georgia in March. During the December-January South Georgia Survey, 1926–7, it was present at nearly all stations; its distribution in this survey as found by the N 100 H nets is shown in Fig. 97. It was particularly abundant at Sts. 136, 137, 138, to the east of the island, and St. WS 43 to the south-west. It was only taken at one station and in small numbers between South Georgia and the Falkland Islands. It was abundant at St. 161 far to the south-west of South Georgia.

Table XXXVI

The depth distribution of Limacina helicina *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	52	84	12·4
100–50	70	81	17·3
250–100	13	33	2·6
500–250	5	29	0·7
750–500	2	21	0·4
1000–750	1	17	0·2

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[1] Massy (1920).

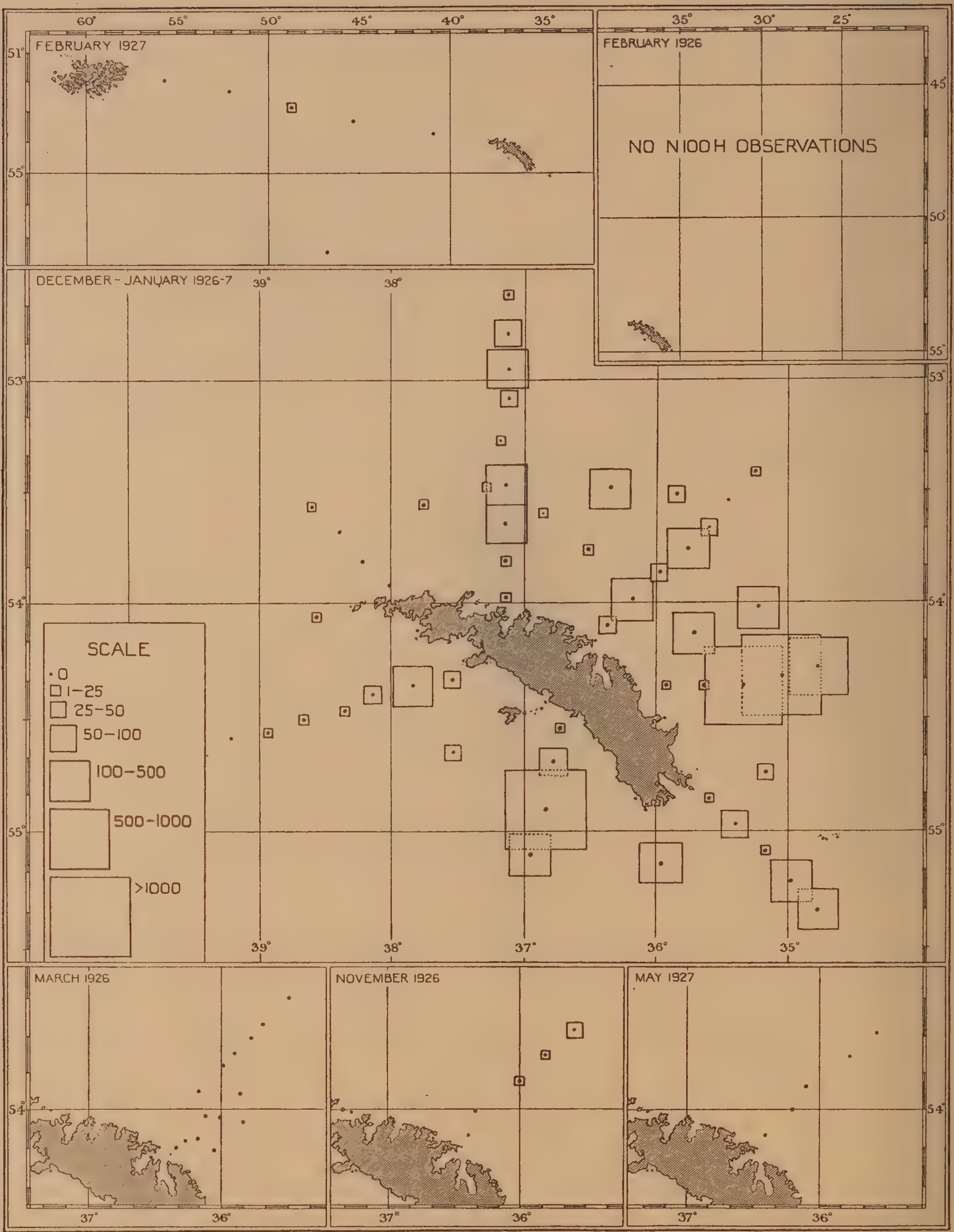
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1927
35°
30°
25°
FEBRUARY 1926
45°
NO N100H OBSERVATIONS
50°
55°
DECEMBER - JANUARY 1926-7
39°
38°
53°
54°
SCALE
· 0
□ 1–25
□ 25–50
□ 50–100
□ 100–500
□ 500–1000
□ >1000
55°
39°
38°
37°
36°
35°
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°
37°
36°
37°
36°

Fig. 97. Charts showing the distribution of *Limacina helicina* at stations in the 1926–7 surveys. The squares represent the numbers taken in three N 100 H nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

Very few were taken in May off the north-east coast of South Georgia, when its place was taken by *L. balea*.

It was not taken in large numbers by the N 70 V nets, but nevertheless from these results we can obtain a good idea of its vertical distribution as shown in Table XXXVI.

It will be seen that it is an inhabitant of the cold surface layer. The table should be compared with the charts of temperature and salinity in Figs. 7 and 8. It is also common in the cold polar currents of the Arctic. There are indications that this species makes a diurnal vertical migration: this is discussed and illustrated on pp. 240 and 257.

It has been commonly taken in the plankton catches of a number of Antarctic expeditions: Belgica,[1] Southern Cross,[2] National Antarctic (Discovery)[3] Gauss[4] and Terra Nova.[5]

A complete record of its occurrence is given in Appendix II.

Limacina juv. Specimens of *Limacina* too young to identify were abundant, particularly to the west of South Georgia. A record of their occurrence is given in Appendix II.

Spongiobranchea australis, d'Orbigny. This species was widely distributed throughout the area but was never abundant. It has been taken previously by the Challenger,[7] Belgica,[1] Southern Cross,[2] National Antarctic (Discovery),[3] Gauss,[4] Terra Nova[5] and Aurora[6] Expeditions. A complete record of its occurrence is given in Appendix II.

ECHINODERMATA

The almost complete absence of any larval forms of bottom-living animals except Crustacea was a striking feature of the plankton samples throughout the area. This feature has been noted by many previous Antarctic expeditions, and many examples of animals, whose relations in other waters possess pelagic larval stages, have been described rearing their young in protective brood pouches. This phenomenon will be further discussed in relation to the hypothesis of animal exclusion in a later part on p. 358. The only Echinoderm larva met with was a single specimen of the large and beautiful *Auricularia antarctica*, MacBride, taken at St. 125 at a depth of 250–100 m. A single specimen of this larva was taken by the National Antarctic (Discovery) Expedition (MacBride, 1912), and fifteen specimens by the Gauss (Mortensen, 1913) at twelve Antarctic stations.

TUNICATA

Salpa fusiformis, var. *aspera* (Cham.). Salps formed a prominent feature of the plankton of the area, often occurring in enormous numbers, and at times making the sorting of the catch very difficult. At St. WS 38 10,730 were taken in a single surface haul with the N 100 H net. They were all of one species, *S. fusiformis*, and all those examined closely appeared to belong to the form *aspera*, but other forms may have been present.

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[1] Pelseneer (1903).
[2] Smith (1902).
[3] Eliot (1907).
[4] Meisenheimer (1905).
[5] Massy (1920).
[6] Hedley (1916).
[7] Pelseneer (1887).

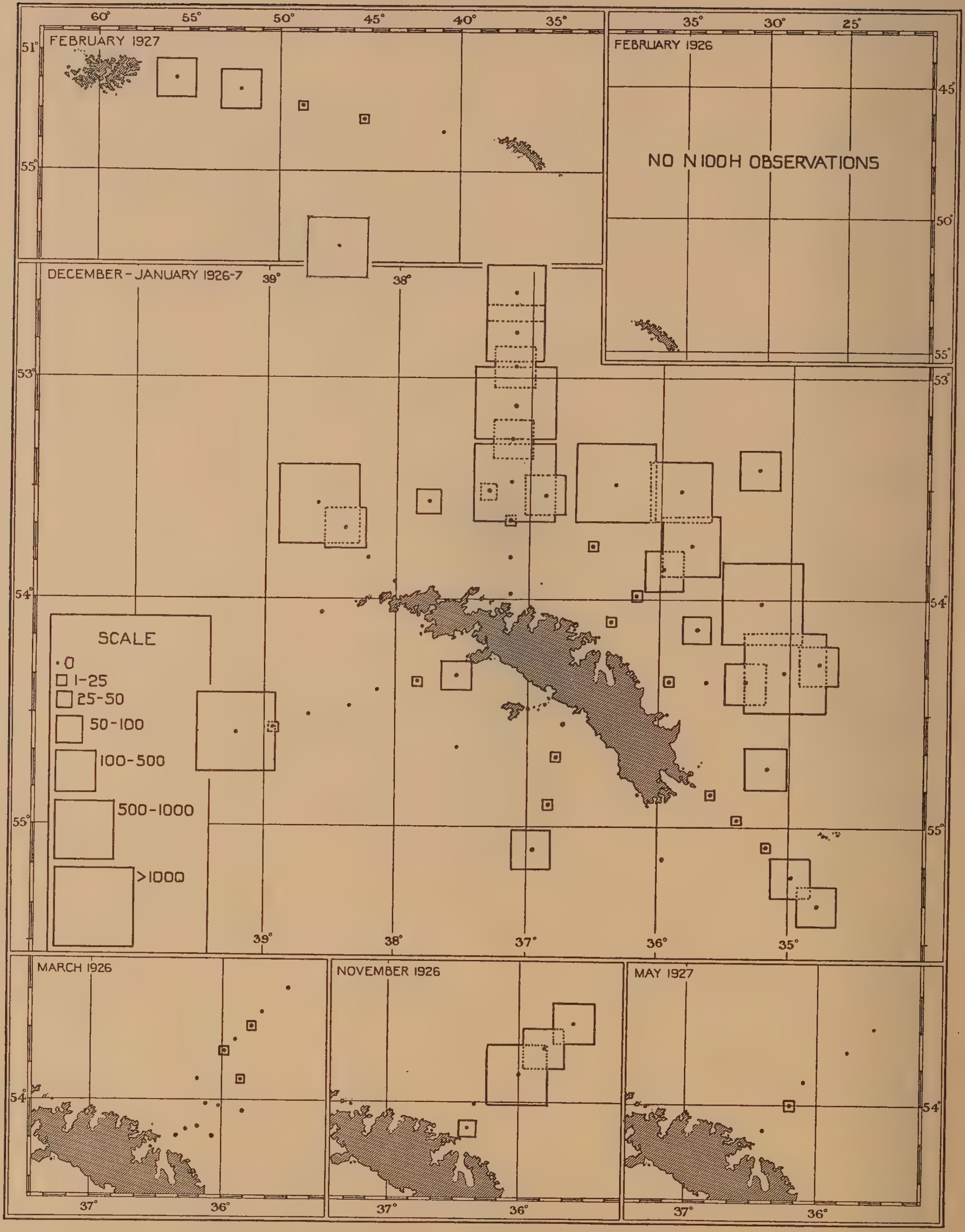
FEBRUARY 1927
60°
55°
50°
45°
40°
35°
51°
55°
FEBRUARY 1926
35°
30°
25°
45°
50°
55°
NO N 100 H OBSERVATIONS
DECEMBER - JANUARY 1926-7
39°
38°
37°
36°
35°
53°
54°
55°
SCALE
• 0
1-25
25-50
50-100
100-500
500-1000
>1000
MARCH 1926
NOVEMBER 1926
MAY 1927
54°
37°
36°

Fig. 98. Charts showing the distribution of *Salpa fusiformis* at stations in the 1926–7 surveys. The squares represent the numbers taken in three N 100 H nets each towed for one mile at approximately 5, 60 and 120 m. depth respectively. For hydrological and phytoplankton conditions see Figs. 2, 6, 7, 8, 38, 39 and 41.

A special report on the pelagic Tunicata is being undertaken by Professor W. Garstang. The species is patchy in its distribution, as is shown by the series of consecutive net hauls described on p. 256 and illustrated in Fig. 135. It will be seen that the patches are considerably larger than those of the Euphausians. This patchiness must be taken into account when considering the distribution as revealed by our stations; one station may have been taken in a patch, another between two patches. Again, the species appears to exhibit a marked vertical migration towards the upper layers at night, and this also must be kept in mind and the chart of distribution in Fig. 98 compared with the chart of night stations in Fig. 89. This vertical migration is further discussed and illustrated on pp. 240 and 151. In spite of these difficulties there can be little doubt that the species is present in larger numbers over the deeper water beyond the edge of the continental shelf. An association between this species and the amphipod *Vibilia antarctica* is described on p. 199.

It was present in much greater numbers early in the season in November, December and January than in March and May.

Its depth distribution as shown by the N 70 V nets is given in the following table: the figures have not been divided into night and day hauls because the distribution is so patchy that it gives misleading results.

Table XXXVII

The depth distribution of Salpa fusiformis *as shown by the N 70 V nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	200	84	47·6
100–50	291	81	71·8
250–100	339	33	68·6
500–250	637 (328)*	29	87·9 (45·2)*
750–500	59	21	11·2
1000–750	114 (11)†	17	26·8 (2·6)†

* Omitting two exceptionally high catches of 158 and 151.
† Omitting one exceptionally high catch of 103.

Salpa fusiformis has been taken in Antarctic waters by the Belgica,[1] Southern Cross,[2] National Antarctic (Discovery)[3] and Gauss[4] Expeditions.

Oikopleura spp. The Larvacea were represented by specimens of *Oikopleura* which have not yet been identified; they will form the subject of a separate report being undertaken by Professor W. Garstang. They were widely distributed in the area but rarely abundant, occurring most frequently in November 1926, and May 1927, off the north-east coast of South Georgia and at the oceanic stations between South Georgia and the Falkland Islands in February 1927.

[1] Van Beneden (1913). [2] Herdman (1902). [3] Herdman (1910). [4] Apstein (1906).

A complete record of their numbers is given in Appendix II.

They occurred in the largest numbers in the top 100 m., as will be seen from the following table, but it is likely that we are dealing with more than one species, one or more of which are inhabiting deeper layers than those found near the surface.

Table XXXVIII

The depth distribution of Oikopleura *spp. as shown by the* N 70 V *nets*

Depth m.	Total number at each depth	Number of net hauls at each depth	Average number per 1000 m. haul in each range of depth
50–0	2236	84	532·4
100–50	3809	81	940·2
250–100	840	33	16·9
500–250	164	29	22·6
750–500	160	21	30·5
1000–750	240	17	56·5

THE ZOOPLANKTON OF DIFFERENT REGIONS WITHIN THE AREA

We have seen (on p. 68) that it was possible to divide the area into a number of regions each of which had a characteristic phytoplankton. For convenience we termed the groups of stations comprising each region a phytoplankton group and numbered them I to V. The distribution of these groups is shown in Fig. 35 and they are made up as follows:

Group I. Water of Bellingshausen Sea origin.
Group II. An area of mixture to the west of the island.
Groups III and IV. Water of Weddell Sea origin and mixture.
Group V. Coastal water.

There are also the stations in the sub-Antarctic Zone across the line of Antarctic Convergence.

We might expect each of these areas to have also a characteristic zooplankton, but actually in general we find surprisingly little difference in their fauna. The average number of the more important organisms taken at the stations within each group is shown in Table XXXIX. Naturally the plankton of the coastal stations and that of the sub-Antarctic stations will differ in some important respects from that of the remaining groups. *Drepanopus*, as we have seen, is a shallow-water coastal form; the copepods *Metridia gerlachei*, *M. lucens* and *Scolecithricella minor* are deep-water forms, likewise the Radiolaria, and these are rarely met with in the coastal regions. The sub-Antarctic stations are marked by an abundance of *Calanus propinquus*, *Ctenocalanus vanus* and *Metridia lucens*, and an absence, or all but absence, of the Antarctic copepods *Calanus acutus*, *Metridia gerlachei* and the Euphausians *E. superba* and *E. frigida*. The zooplankton content of the remaining groups has a remarkable sameness, although we may note that *Euphausia superba*, *E. frigida*, *Limacina helicina* and *Salpa fusiformis* are more abundant in the Weddell Sea water groups than in that of the Bellingshausen Sea water, or the water of its mixture in Group II. The distribution of the zooplankton organisms in relation to the phytoplankton will be further discussed in Part V.

Table XXXIX

Showing the average number of the principal zooplankton species taken at stations in the different phytoplankton groups. Outstanding features shown in heavy type.

	Phytoplankton Group I Bellingshausen Sea water	Phytoplankton Group II Mixture	Phytoplankton Group III	Phytoplankton Group IV	Phytoplankton Group V Coastal water	Sub-Antarctic Zone Sts. WS 68–70
			Weddell Sea water and mixture			
Number of stations averaged...	4	6	14	15	4	3
N 70 V*						
Foraminifera	**262**	54	58	**754**	78	152
Radiolaria	82	1	39	33	**0**	51
Eukrohnia hamata	5	3	11	7	4	35
Pelagobia longicirrata	78	37	22	89	46	0
Calanus simillimus	15	16	11	25	28	60
C. propinquus	44	39	32	77	18	**1030**
C. acutus	**292**	69	28	**294**	205	**1**
Rhincalanus gigas	39	10	34	16	10	20
Ctenocalanus vanus	**999**	107	202	**473**	116	**589**
Drepanopus pectinatus	47	1879	817	1671	**9691**	0
Scolecithricella minor	34	4	13	14	**1**	93
Metridia gerlachei	3	5	5	15	**0**	0
M. lucens	64	3	12	13	**0**	**720**
Oithona frigida	**6957**	1633	1764	2970	1262	2056
N 100 H						
Parathemisto gaudichaudi	75	29	78	140	60	71
Euphausia frigida	24	1	61	12	5	**0**
E. superba	97	2	**1158**	**733**	221	**0**
Thysanoessa spp.	162	136	78	39	13	**4**
Limacina helicina	0	60	80	**482**	35	2
Salpa fusiformis	472	9	**630**	**982**	5	242

* Numbers given for the top 250 m. only expressed as an average per 50 m. haul.

VERTICAL MIGRATION

The diurnal vertical migrations of plankton animals have been known and studied in the northern hemisphere for many years. Russell, who has made such detailed studies of these movements in the Plymouth area, published (in 1927*a*) a general survey of the subject up to that time giving a very full bibliography. Since then a number of other papers have appeared, amongst which may be mentioned those by Russell (1927–34), and by Gardiner (1933 and 1934), Nicholls (1933) and Clarke (1933).

From the data collected in our present survey we have been able to determine in broad outline the vertical migrational behaviour of the more important plankton animals in the South Georgia area. Whilst a few species show little or no such migration it may be said that in general vertical migration is a marked characteristic of the Antarctic zooplankton. The possible ecological significance of this vertical migration will be discussed in Part V, pp. 332–356; here the data relating to the different species will be described in detail.

Methods of investigation

The knowledge of the vertical migrational behaviour of the different organisms has been obtained in three ways.

At St. 41, 16 miles off the north-east coast of South Georgia, the 'Discovery' anchored in 272 m. of water in an attempt to carry out repeated observations on the plankton throughout a period of 24 hours. The object of this attempt was twofold: to study the diurnal changes in the vertical distribution of the plankton if any, and also by repeating hauls at intervals to obtain a "control" on the validity of the single observations made at other stations. The "control" results will be discussed in a subsequent section, here we will deal with the vertical changes. N 70 V nets were used at the following depths: 265–150 m., 150–100 m., 100–50 m. and 50 m. to the surface. The first series of hauls were made at 1300–1345 o'clock and repeated at 1540–1605 o'clock, 1700–1728 o'clock, 1910–1955 o'clock, and 2105–2140 o'clock. The series began in almost perfect weather, with the sea calm, but by 1530 o'clock the wind had freshened and there was a slight northerly swell, and 6 hours later the wind was blowing with a force of 5–6 and the sea had risen to 4–5 with a heavy northerly swell. A full gale rapidly developed, so that the experiment had to be abandoned. Another opportunity for a similar experiment did not occur. Our information regarding the diurnal migration of the zooplankton at this station is then based upon these five repeated series of hauls from soon after midday until some 3 hours after darkness. This information by itself is of limited value since we know from the results of former workers that the vertical migrational behaviour of animals is usually by no means fixed, but varies under different conditions; the results however are valuable when taken in conjunction with those obtained by the other two methods.

In the second method the average percentage occurrence of different species at different levels in the series of vertical hauls taken at stations throughout the survey between the hours of 0600 and 1759 o'clock were compared with corresponding average percentages for stations taken between the hours of 1800 and 0559 o'clock. Only those stations were included which had a sufficient number of the species in question.[1] The data for shallow water stations, i.e. stations in water of depth 200–300 m., approximately equal to that of St. 41, were separated from the data for deeper water stations. This method gives a more general indication of the behaviour of different species, since it averages the results of a number of stations taken under different conditions. The results by this method are shown alongside those from St. 41 for comparison in a number of figures, of which Fig. 101 is an example.

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[1] A minimum number of 100 per 50 m. haul was chosen for this purpose, except in the case of *Calanus simillimus* where a minimum number of 50 was used.

The third method was to construct charts showing the depth distribution of different species in the series of horizontal hauls with the N 70 H and N 100 H nets at all stations in the survey, such stations being arranged in a line in order of the time of day from noon, through the afternoon, night and morning and back to noon again. Figs. 99 and 120 show examples of such charts for the N 70 H and N 100 H nets respectively. These nets, it will be remembered, were towed horizontally in a series, one at the surface, one at approximately 60 m. and another at approximately 120 m. The actual depths were determined by the reading of a Kelvin tube fastened to the warp above the stream-line lead at the bottom of the warp. The depths recorded varied considerably, often due to the difficulty of regulating the slow speed of the ship in rough weather, and occasionally the bottom net would reach 200 m. On the chart below the appropriate station number the depth of each net haul is shown by the position of a figure indicating the number of the particular organism in the haul, or of a dot if no such organisms were present. This method shows in considerable detail the general vertical migrational behaviour of the different animals. It shows the actual times of their rise and fall, whether this rise and fall is gradual or rapid, and whether it occurs in some species with regularity or in others irregularly. Like the second method this has the merit of presenting a picture based upon a large number of stations taken under different conditions throughout the area, and so gives an indication of the average or normal behaviour of the animals. The series includes stations taken at different seasons; whilst most of them are taken in December and January, some are taken in March and a few in May. This accounts for the, at first sight, curious separation of St. WS 110 (late May) and St. 25 (March) from the rest of the stations taken in darkness in the 24-hour scale; the parts of the chart representing hauls taken between sunset and sunrise are shaded.

Copepoda

Calanus simillimus shows a most marked and rapid vertical migration coming to the surface from depths greater than 50 m. between the hours of 1700 and 1800 o'clock. The results from St. 41 (Fig. 101) and those from the N 70 H nets at all stations (Fig. 99) confirm one another. From the latter observations it would seem that the upward movement through at least 50 m. of water may be carried out in less than an hour's time, indicating an upward speed of at least a metre a minute and probably very much faster. It comes to the surface earlier in the evening than does any other copepod, except perhaps *Drepanopus pectinatus* which also makes a very rapid ascent. The behaviour of these two copepods is very similar, as will be seen by comparing the figures which are placed together for this purpose. *Calanus simillimus* may remain in moderate numbers at the surface until between 7 and 8 o'clock in the morning, but the bulk of them appear to sink at the approach of 2 or 3 o'clock.

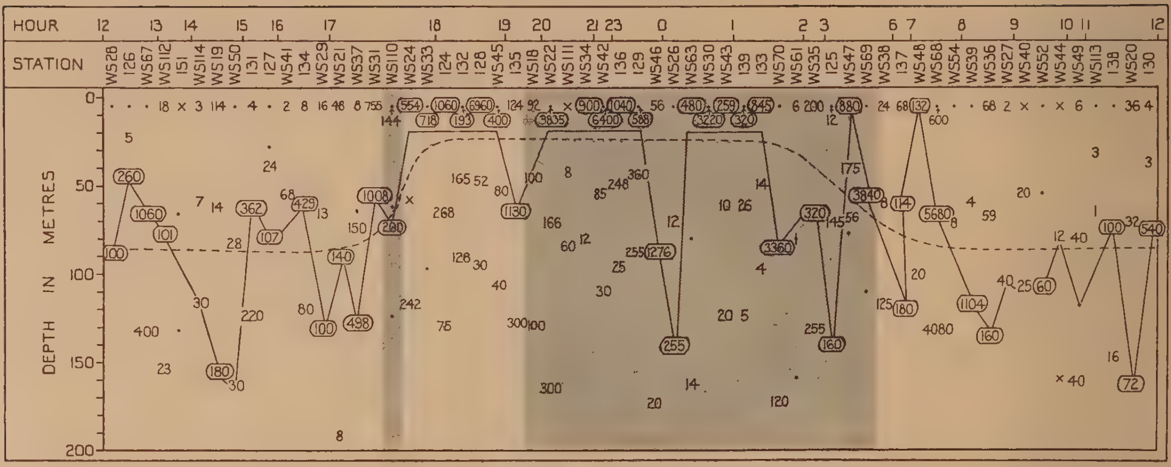

Fig. 99. Chart showing the diurnal depth distribution of *Calanus simillimus* as sampled by the series of N 70 H nets. All N 70 H stations have been arranged in order of time of day from noon to noon, and the depth position of each net shown either by a number representing the *C. simillimus* taken or by a dot indicating no *C. simillimus* taken. The shaded portions of the chart represent stations taken between sunset and sunrise (the separation of St. WS 110 from the rest of the night stations is due to this station being taken in May, i.e. the late autumn, whereas most of the other stations are taken in December–January). The unbroken line connects the maximum number at each station, and the broken line indicates the approximate normal vertical migration of the species.

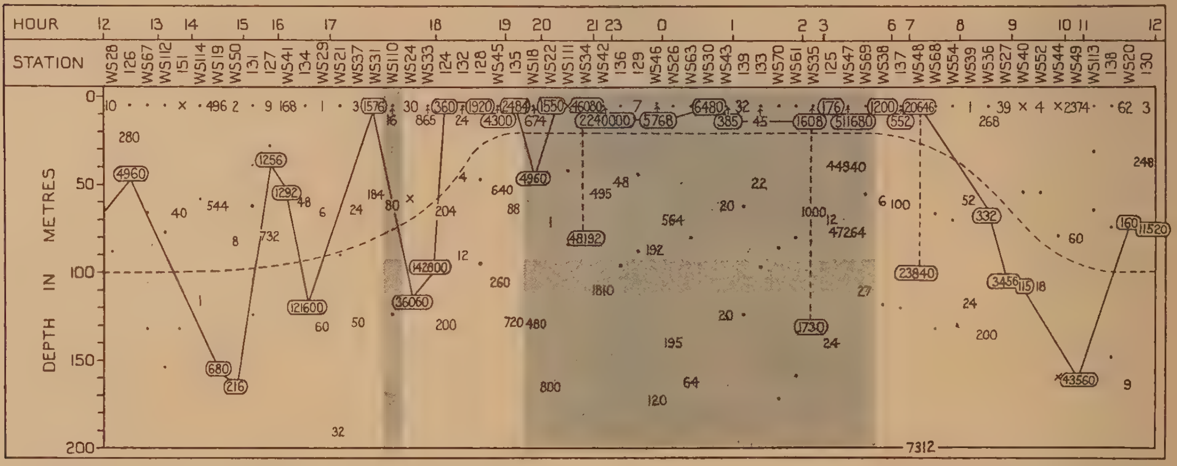

Fig. 100. Chart showing the diurnal depth distribution of *Drepanopus pectinatus*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

Calanus propinquus does not show such a regular migration as does *C. simillimus*, nor does it come to the surface so early or so rapidly; but it comes more usually from a somewhat greater depth. In Fig. 103 the irregularity of its migrational behaviour may be judged from the continuous line which connects the positions of the net hauls containing the greatest numbers at each station; at some stations at night they are up and some down, nevertheless a general trend of migration can be seen which is indicated by the broken line. The large numbers taken in the deepest net at St. WS 70, marked with

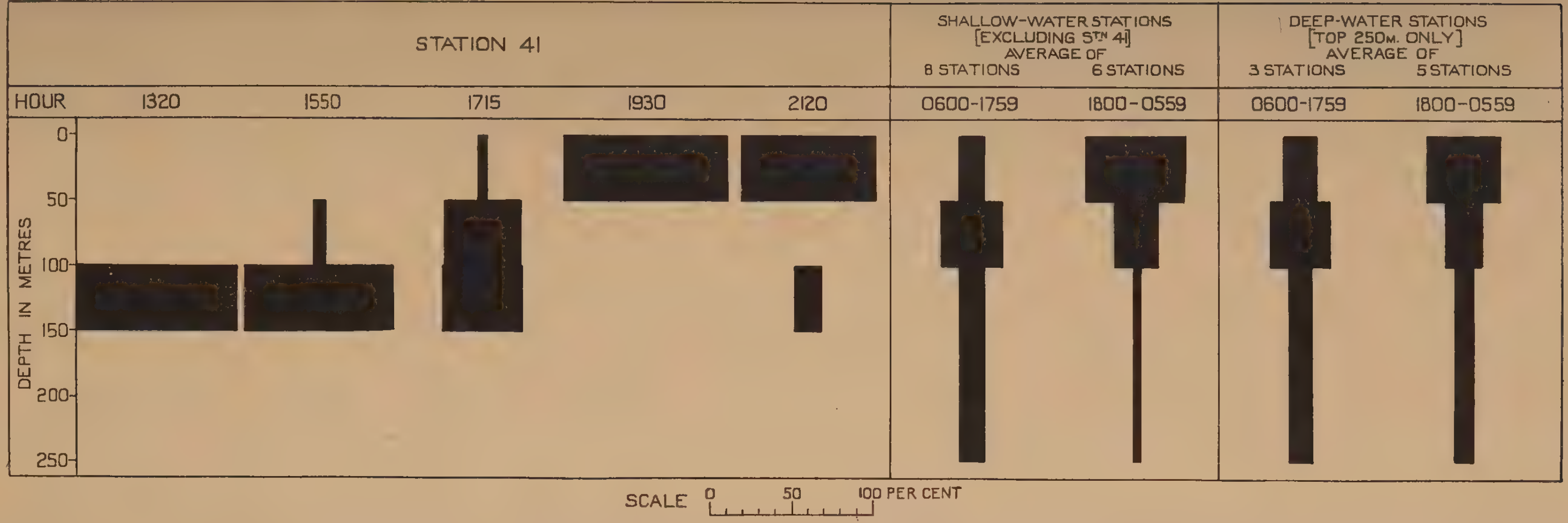

Fig. 101. Chart showing the vertical distribution of *Calanus simillimus* expressed as percentages per 50 m. vertical haul with N 70 V nets at different depths at five different times, 1320–2120, at St. 41, and similarly the average percentage vertical distribution per 50 m. haul for the top 250 m. at day and night stations taken in shallow water and over deep water.

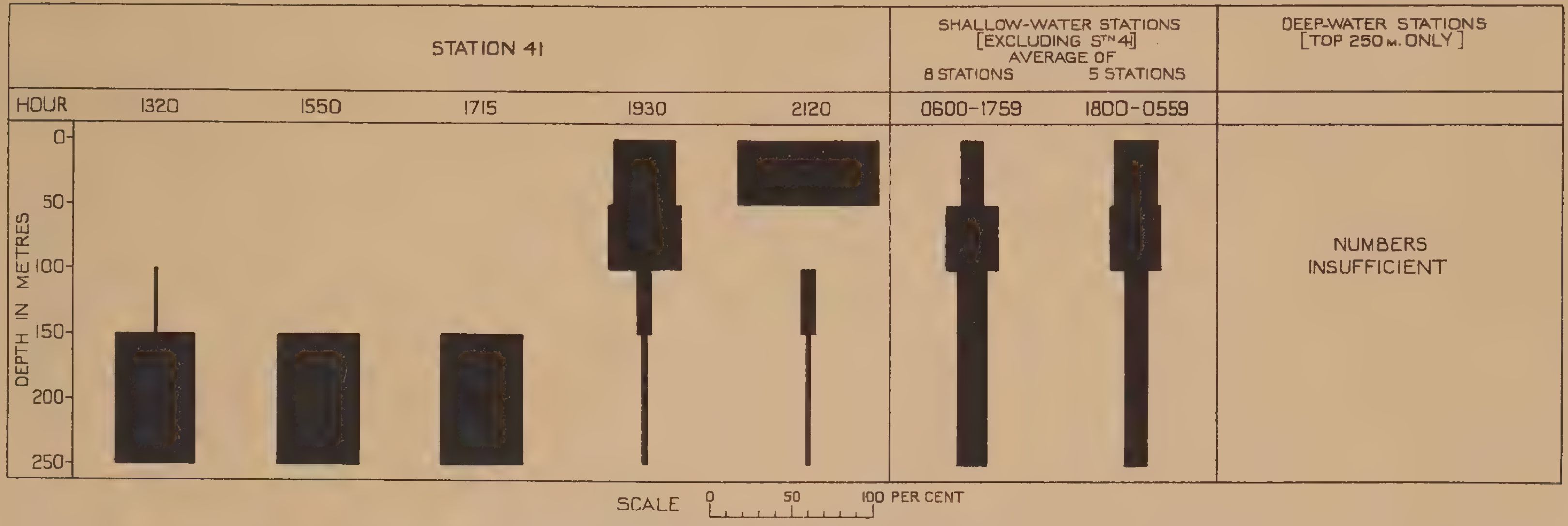

Fig. 102. Chart showing the vertical distribution of *Drepanopus pectinatus* expressed as percentages per 50 m. vertical haul with N 70 V nets at different depths at five different times, 1320–2120, at St. 41, and similarly the average percentage vertical distribution per 50 m. haul for the top 250 m. at day and night stations taken in shallow water and over deep water.

an asterisk in Fig. 103, should be disregarded in considering the normal migration, for this station is beyond the line of Antarctic Convergence, where the Antarctic water has dipped down below the sub-Antarctic water. At St. 41 (Fig. 106) the migration was marked, likewise in the results from the consideration of the average percentage vertical distribution at the deep water stations, but not so at the shallow water stations; this provides a confirmation of its irregular behaviour.

Calanus acutus, whilst showing considerable variation in its vertical distribution at different stations, shows no regular diurnal migration. This is well shown in Fig. 108, where the continuous line connects the positions of the net hauls containing the greatest numbers at each station; although actually more are taken at the surface at night than in the daytime no regular migration can be detected. This is confirmed by the results of the other two methods shown in Fig. 111; the average night and day distribution at the shallow stations is the reverse of that at the deep-water stations, showing that the variations in depth distribution are not regular diurnal ones, and the results from St. 41 show no upward movement at all. These specific differences in behaviour within the genus *Calanus* are interesting, and will be referred to again in Part V of the report (p. 312). We saw that *C. simillimus* approached *Drepanopus pectinatus* in behaviour; *Calanus acutus* is similar in behaviour to *Rhincalanus gigas* and *Oithona frigida*; the figures illustrating these species are shown in juxtaposition for comparison.

Rhincalanus gigas comes into the top 50 m. of water. Whilst there appears to be some vertical movement apparent in the observation at St. 41 (Fig. 112), it does not represent a regular rise and fall with the approach of darkness, and results from the other two methods (Figs. 112 and 109) show clearly that this species has no true diurnal vertical migration.

Clausocalanus laticeps, which was not taken in sufficient numbers in the N 70 V nets to allow the first two methods of investigation to be used, shows in the N 70 H results (Fig. 105) a most definite and gradual rise and fall from below 100 m. to the surface. It begins its journey upwards soon after 1700 o'clock, and reaches the surface just before midnight, and falls again at 0300 o'clock.

Ctenocalanus vanus displays a diurnal migration, Figs. 104 and 107, but like *Calanus propinquus* it is by no means regular in its behaviour, although it tends to come to the surface in large numbers between midnight and 0200 o'clock.

Drepanopus pectinatus, shown in Figs. 100 and 102, has a marked vertical migration similar in character to that of *Calanus simillimus*, although it remains longer at the surface in the early hours of the morning. It remains near the surface for a longer period than any other species investigated by us, and together with *C. simillimus* arrives at the surface earlier than any other form.

Pareuchaeta antarctica (Fig. 120), *Scolecithricella minor* (Figs. 115 and 116), *Pleuromamma robusta* (Fig. 119), *Metridia gerlachei* (Figs. 115 and 117) and *M. lucens* (Figs. 115 and 118) are all forms inhabiting deeper water in the daytime but making a rapid and considerable migration into the upper layers during the hours of darkness. The rapidity with which these forms must rise and sink is clearly shown in the figures for the N 70 H and N 100 H results. Very few specimens are taken during the hours of daylight, but as soon as darkness sets in the nets begin to capture them in large numbers. The possibility that the animals are avoiding the nets during the daytime, so that such apparent migrations are not real, is discussed on pp. 244 and 250, where the conclusion is reached that these extensive migrations are actually taking place. Fig. 115 shows a vertical migration of *Scolecithricella minor* extending over some 500–700 m. It seems scarcely possible that so small a copepod could rise some 2000 feet in a few hours by locomotive power alone. It seems likely that some change in specific gravity must occur.

Microcalanus pygmaeus (Fig. 115) shows little or no migration. The slight difference between the night and day results may not signify a regular diurnal movement.

Oithona frigida (Figs. 110 and 113) only rarely occurs in any considerable numbers in the upper 50 m. of water, and like *Calanus acutus* and *Rhincalanus gigas* it shows no sign of a regular diurnal migration. The results for all three methods of investigation confirm this conclusion.

Amphipoda

The Amphipod *Parathemisto gaudichaudi* (Fig. 121) shows a gradual rise towards the surface beginning some 3 hours before darkness, and a corresponding fall in the early hours of the morning after sunrise. Occasionally during the daytime moderate numbers are to be found at the surface, as many as 464 being recorded soon after 12 noon on one occasion, but for the most part in the daytime the numbers taken in the upper 50 m. are small. During the night the majority of hauls taken in the surface waters record large numbers—on some occasions over 2000.

In the case of *Vibilia antarctica* (Fig. 124), although the number of observations is small, we see a definite rise to the surface waters from just before midnight till about 4 o'clock in the morning, a behaviour which is similar to that shown by *Salpa fusiformis* (Fig. 123). We have already suggested on p. 199 that there is an association between these two forms.

We have very few observations regarding *Cyllopus*, but Fig. 122 shows that most of the specimens taken in the upper layers have been taken during the hours of darkness. On very few occasions has this form been met with in the surface net during the daytime.

Euphausiacea

The behaviour of *Euphausia superba* appears to be very erratic, but we see from Fig. 127 that far more specimens are taken at the surface during the hours of darkness than during daylight. Three prominently high catches were taken at the surface during daylight at Sts. 40, 41 and 43, and it is perhaps noteworthy that all these three stations were taken in the same week at the end of March and the beginning of April; this is late in the season, when the light is weaker than in the middle of the Antarctic summer, and at this time the migration may be less marked.[1]

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[1] This phenomenon is reconsidered on p. 326 in Part V and a relation with phytoplankton conditions tentatively suggested.

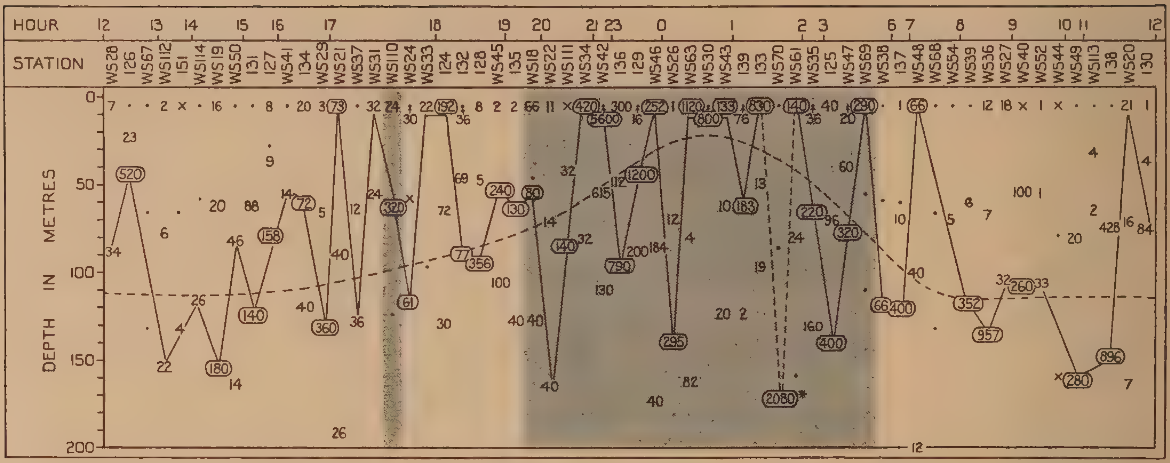

Fig. 103. Chart showing the diurnal depth distribution of *Calanus propinquus*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

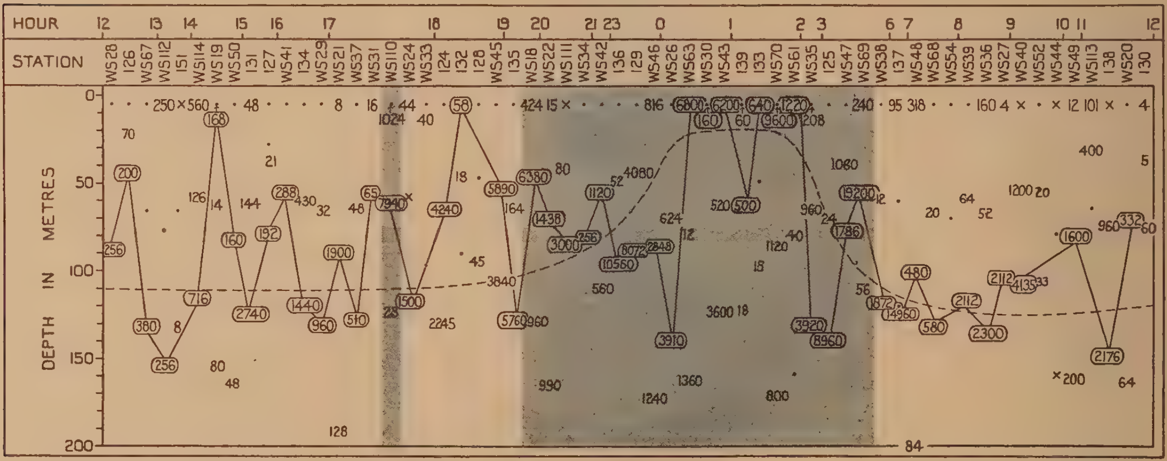

Fig. 104. Chart showing the diurnal depth distribution of *Ctenocalanus vanus*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

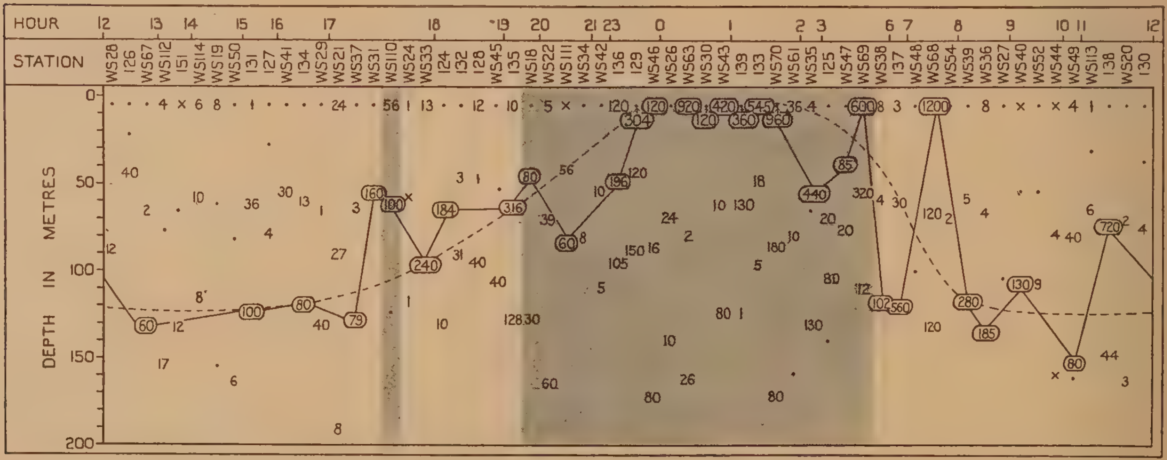

Fig. 105. Chart showing the diurnal depth distribution of *Clausocalanus laticeps*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

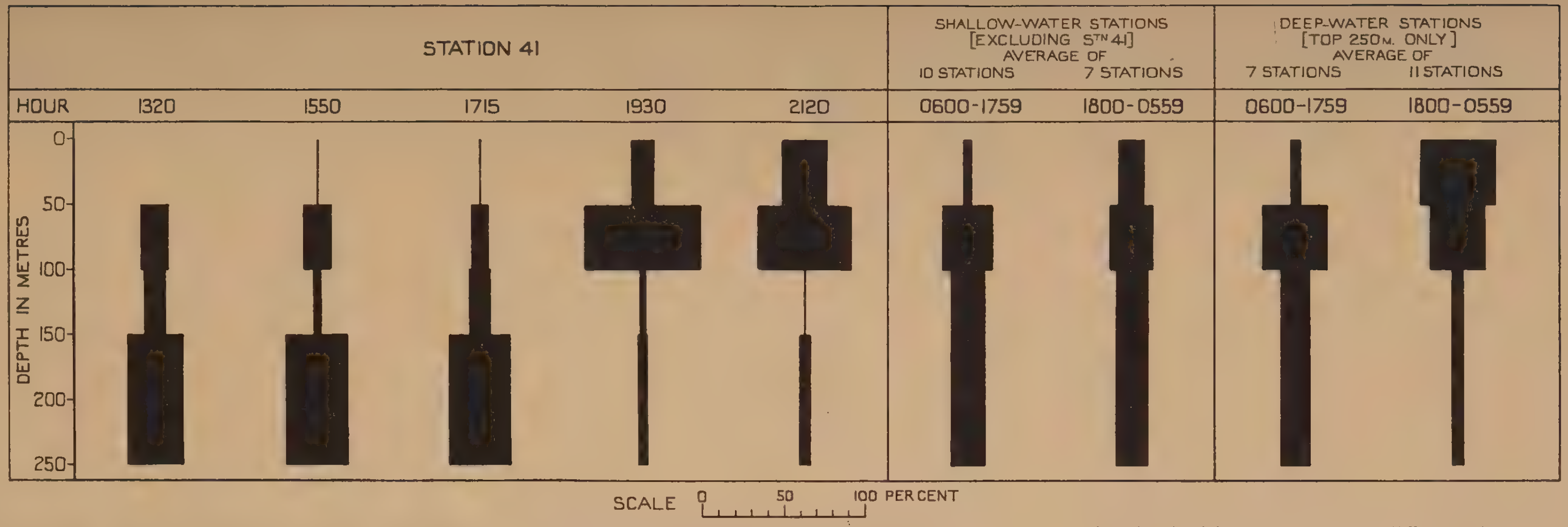

Fig. 106. Chart showing the vertical distribution of *Calanus propinquus* expressed as percentages per 50 m. vertical haul with N 70 V nets at different depths at five different times, 1320–2120, at St. 41, and similarly the average percentage vertical distribution per 50 m. haul for the top 250 m. at day and night stations taken in shallow water and over deep water.

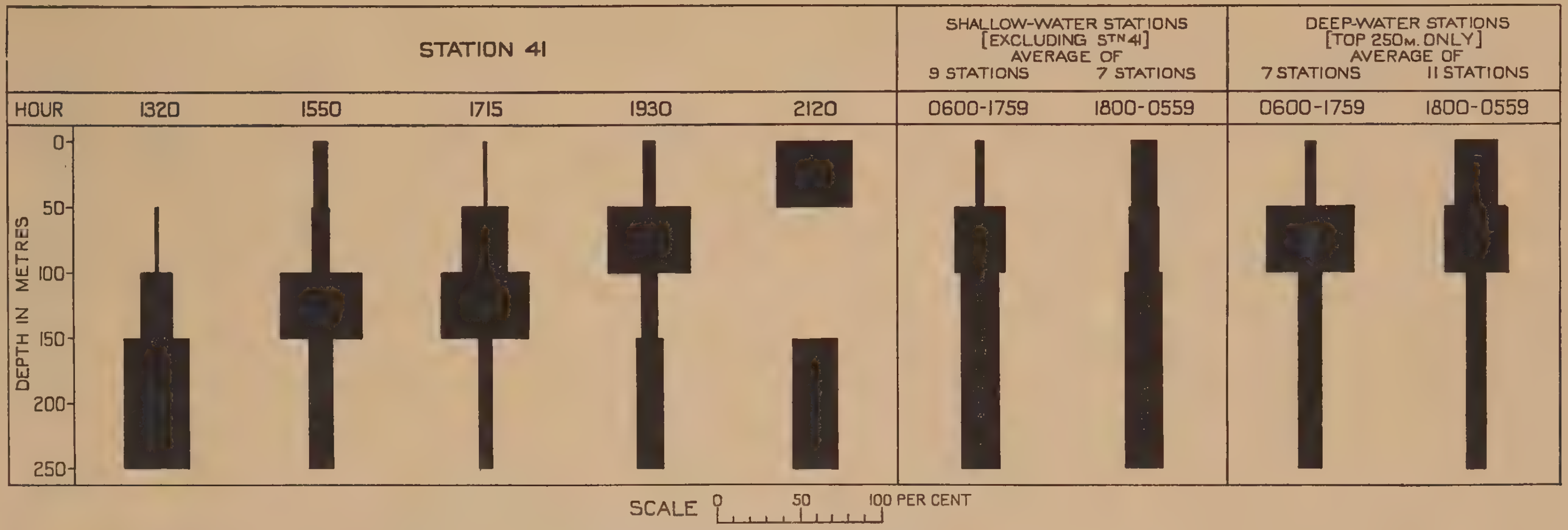

Fig. 107. Chart showing the vertical distribution of *Ctenocalanus vanus* expressed as percentages per 50 m. vertical haul with N 70 V nets at different depths at five different times, 1320–2120, at St. 41, and similarly the average percentage vertical distribution per 50 m. haul for the top 250 m. at day and night stations taken in shallow water and over deep water.

In Figs. 125 and 126 we see a remarkable phenomenon of the almost complete absence of *E. frigida* and of *E. triacantha*, during the hours of daylight in the upper 200 m. of water. As soon as it becomes dark we find them, particularly *E. frigida*, abundant in the upper layers coming to the very surface. It must mean that a vertical migration of some 600 ft. is accomplished in a very short space of time. It may be suggested that these forms definitely avoid the net during the hours of daylight, but are caught in the night when they cannot see the net, but such considerations can hardly apply to other forms which we see making vertical migrations, such as Salps. On other grounds, to be discussed later, this theory of the avoidance of the net is dismissed. We are left in wonder as to how this remarkable migration of 600 ft., in at most an hour or two, is carried out. One would think that it must involve more than power of locomotion, possibly some change in specific gravity.

Thysanoessa, illustrated in Fig. 128, may at first sight show little migration, but it was taken more often at the surface during the hours of darkness than in daylight, and in the middle layers in greater numbers than are usual for daylight hauls, although there are some marked exceptions to this. The two outstanding instances of large numbers being taken at the surface during the daytime are at stations late in the season: St. 40 in April and St. WS 110 in late May; cf. *Euphausia superba*.

Other macroplankton

The chaetognath *Eukrohnia hamata* (Fig. 129) rarely appears in the upper 50 m. of water, and little sign of any regular diurnal migration occurs, although it will be noted that the only two occasions on which it was taken in any considerable numbers at the surface were just before sunset and in darkness.

The Pteropod *Limacina helicina*, illustrated in Fig. 130, shows a gradual tendency of movement towards the surface from 1700 to 2200 o'clock, and a corresponding movement downwards from 0200 to 0700 o'clock.

We also see a marked general tendency for *Salpa fusiformis* (Fig. 123) to come to the upper layers during darkness, particularly in the early hours of the morning from midnight until 0400 o'clock. This somewhat delayed migration we see corresponds to that of the Amphipod *Vibilia*, and, as we have already noted, we suspect there is an association between the two.

Recent confirmation

Since this work was done Mackintosh (1934) has published a report on the distribution of the macroplankton in the Atlantic sector of the Antarctic based on the examination of collections made over a wide area by 100 cm. diameter nets hauled obliquely from 100 m. to the surface. He finds considerable diurnal variation in the numbers of the majority of animals due to their vertical migration into the path of the nets at night and away from them in the daytime. He was dealing with the macroplankton only, the smaller species not being caught by these 100 cm. oblique nets.

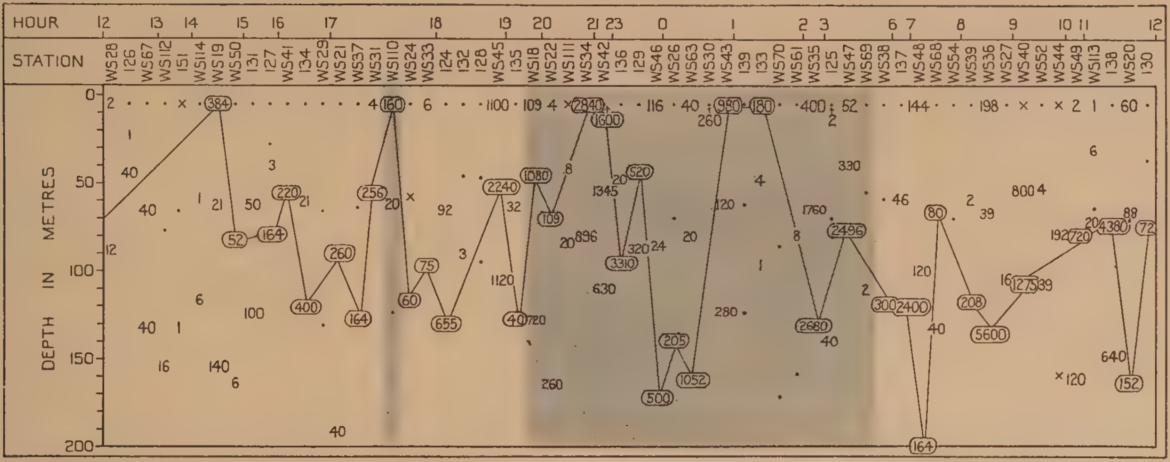

Fig. 108. Chart showing the diurnal depth distribution of *Calanus acutus*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

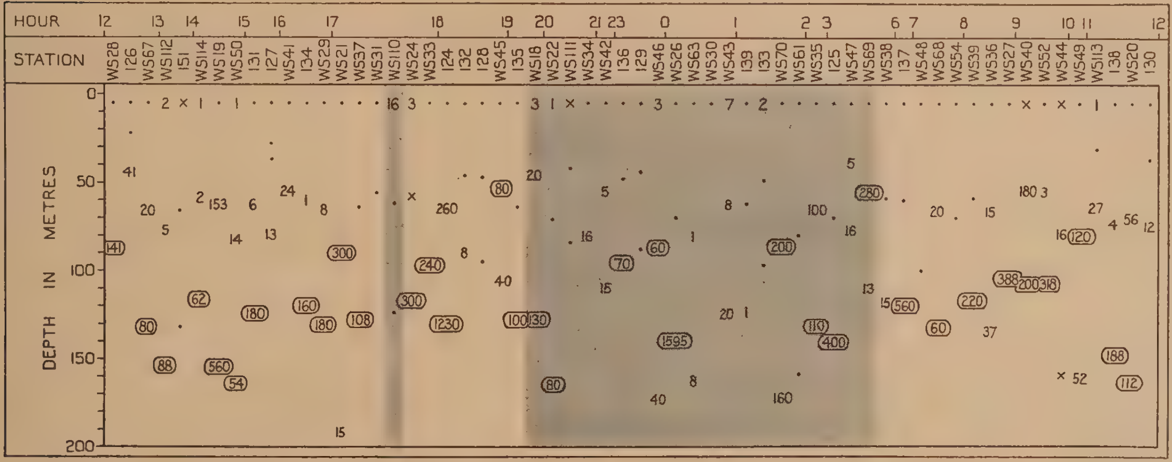

Fig. 109. Chart showing the diurnal depth distribution of *Rhincalanus gigas*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

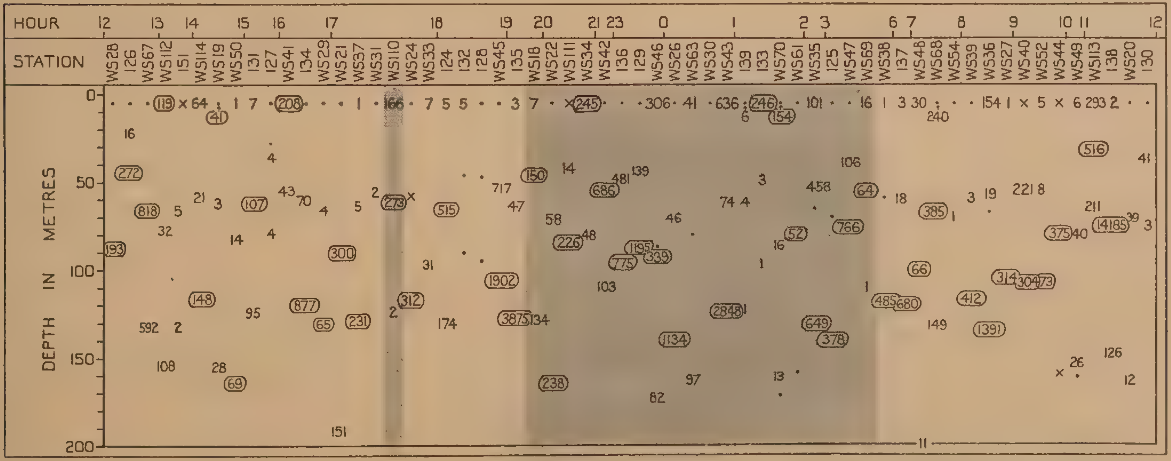

Fig. 110. Chart showing the diurnal depth distribution of *Oithona frigida*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

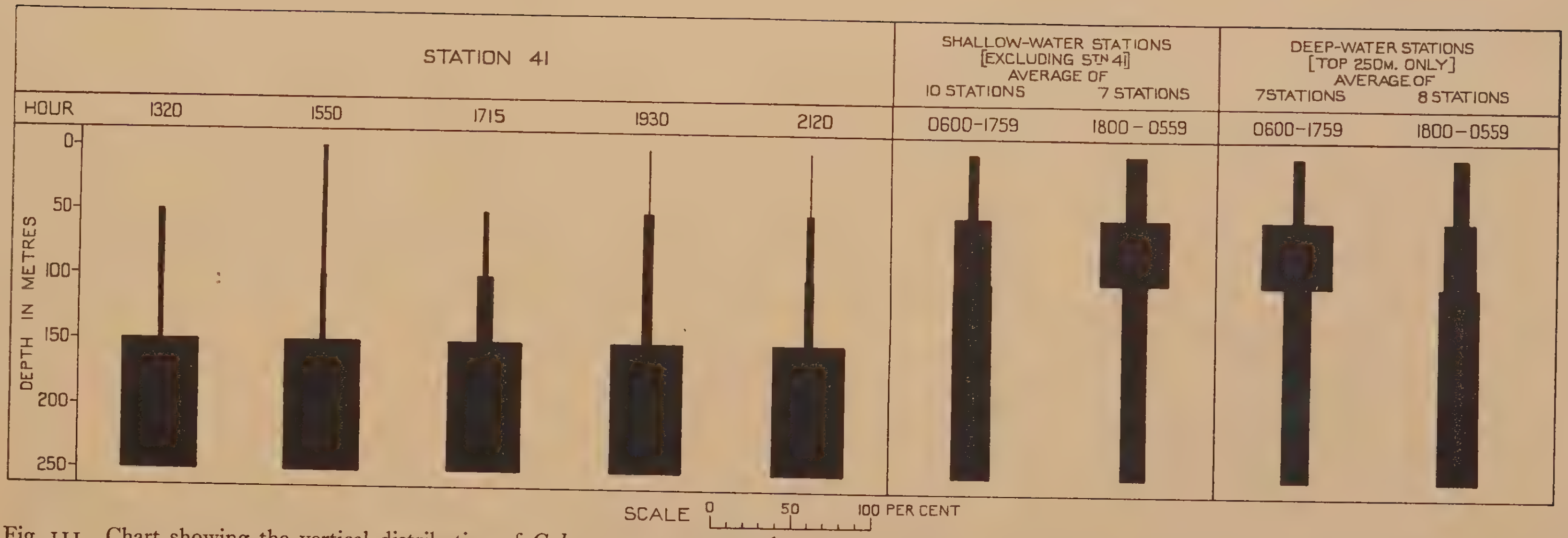

Fig. 111. Chart showing the vertical distribution of *Calanus acutus* expressed as percentages per 50 m. vertical haul with N 70 V nets at different depths at five different times, 1320–2120, at St. 41, and similarly the average percentage vertical distribution per 50 m. haul for the top 250 m. at day and night stations taken in shallow water and over deep water.

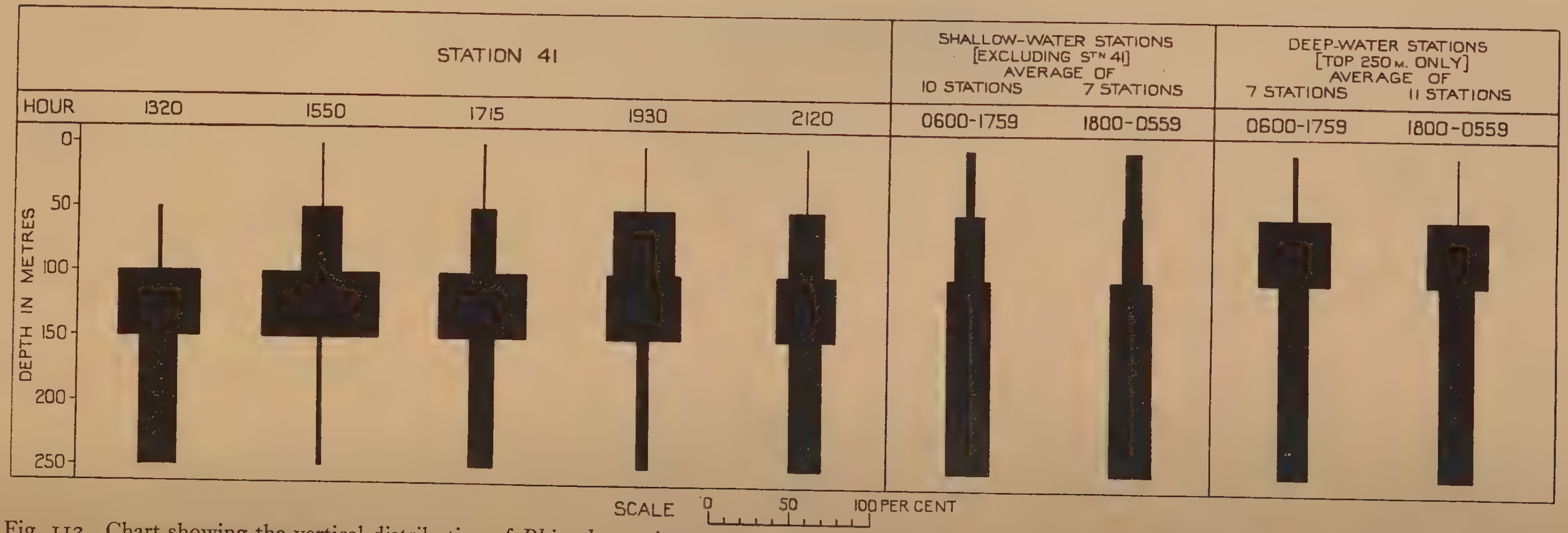

Fig. 112. Chart showing the vertical distribution of *Rhincalanus gigas* expressed as percentages per 50 m. vertical haul with N 70 V nets at different depths at five different times, 1320–2120, at St. 41, and similarly the average percentage vertical distribution per 50 m. haul for the top 250 m. at day and night stations taken in shallow water and over deep water.

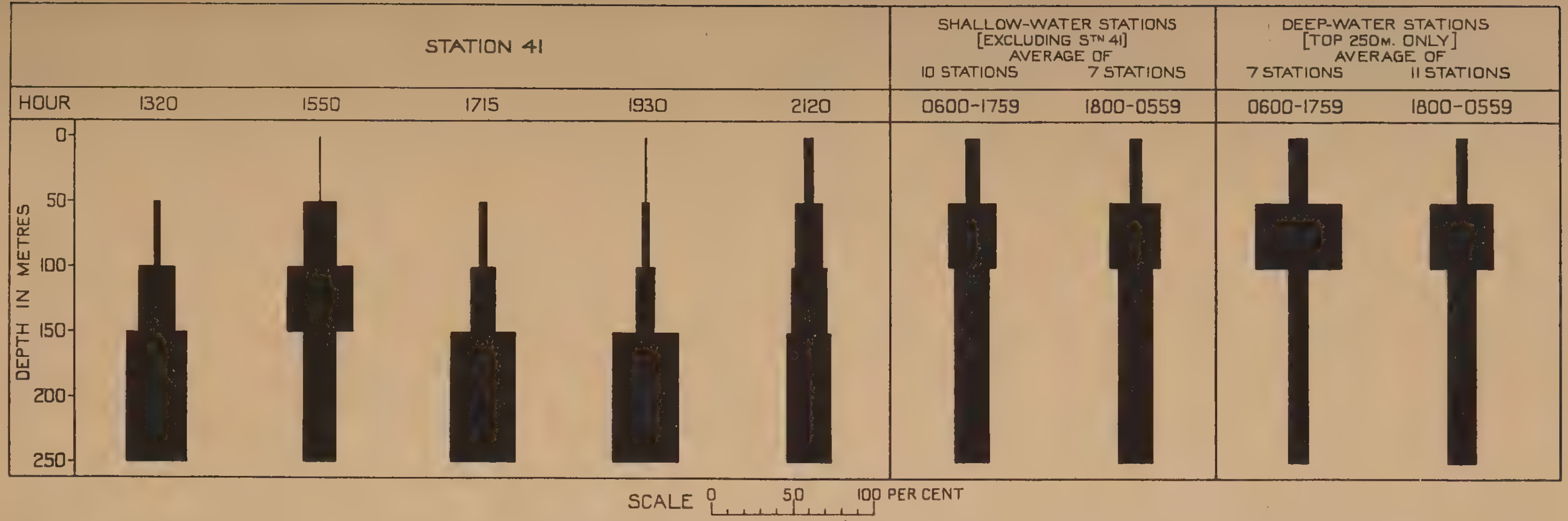

Fig. 113. Chart showing the vertical distribution of *Oithona frigida* expressed as percentages per 50 m. vertical haul with N 70 V nets at different depths at five different times, 1320–2120, at St. 41, and similarly the average percentage vertical distribution per 50 m. haul for the top 250 m. at day and night stations taken in shallow water and over deep water.

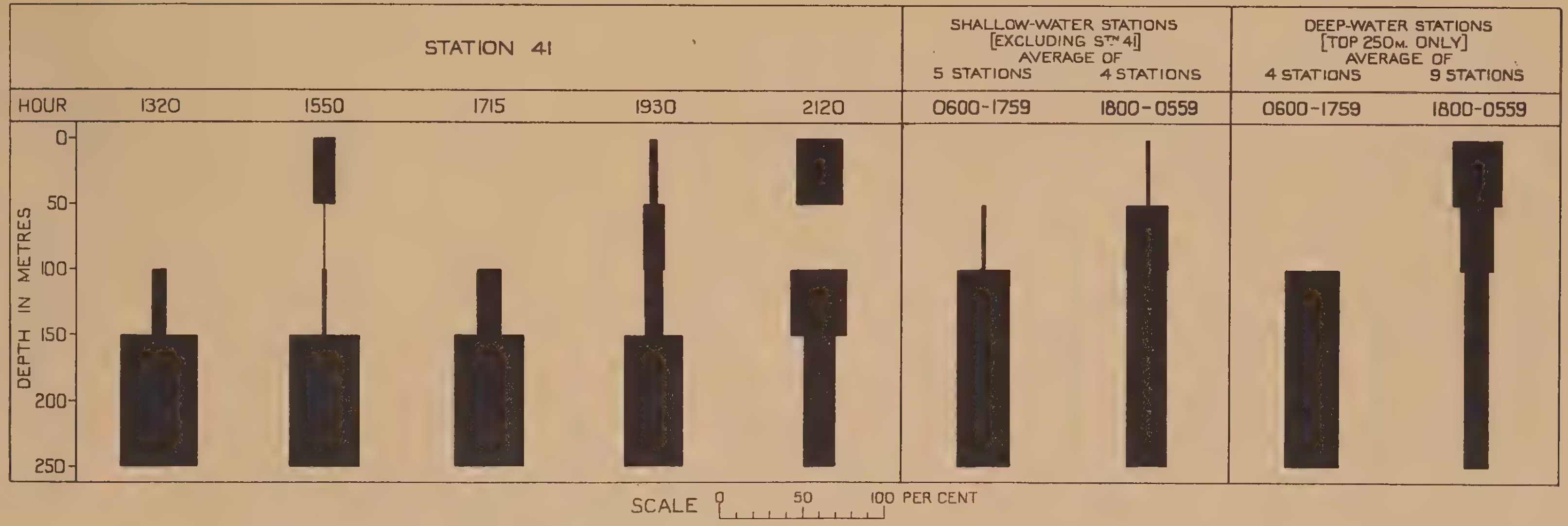

Fig. 114. Chart showing the vertical distribution of *Metridia lucens* expressed as percentages per 50 m. vertical haul with N 70 V nets at different depths at five different times, 1320–2120, at St. 41, and similarly the average percentage vertical distribution per 50 m. haul for the top 250 m. at day and night stations taken in shallow water and over deep water.

In referring to our results he writes on p. 96 as follows:

> Hardy and Gunther (1934)[1] have discussed the vertical migrations of certain species which are included in Table I and conclude that a more or less marked migration is shown by the following species: *Calanus propinquus*, *C. simillimus*, *Metridia gerlachei*, *Pareuchaeta antarctica*, *Parathemisto gaudichaudi*, *Vibilia antarctica*, *Cyllopus* sp., *Euphausia superba*, *E. frigida*, *E. triacantha*, *Thysanoessa* spp., *Limacina helicina*, and *Salpa fusiformis*. Table I shows that all except four of these species also show a clear diurnal variation, and it is therefore mainly in agreement with Hardy and Gunther's results. The exceptions are *Calanus propinquus*, *Parathemisto gaudichaudi*, *Euphausia superba*, and *Limacina helicina*. The explanation of the fact that they show little diurnal variation in the catches of the N 100 B[2] is probably to be explained on the grounds that they inhabit mainly the upper layers, and that their vertical migrations do not take the bulk of them beyond the reach of the net at night. Hardy and Gunther find little or no migration in *Calanus acutus* and *Rhincalanus gigas*, and this also is in agreement with the results expressed in Table I.

The reality of vertical migration

We must now consider the theory that has been advanced from time to time that vertical migration is not a real phenomenon, and that the larger numbers of an animal taken in the nets towards the surface at night are due to the animal being able in daylight to see the net and escape capture. The exceptional catches of some animals at or near the surface during daylight would appear to prove the rule, unless we must imagine that on these occasions they are "asleep". Russell (1933) has shown that a number of forms, including *Calanus*, *Sagitta*, and young fish, which show a marked migration away from the upper layers in daylight during part of the year, may be taken at the surface in bright sunlight in late summer. He suggests that these, belonging to different broods, have a different behaviour; no one would suppose that these broods are less awake or less alive to the danger of the net and so fail to escape.

The tables giving the depth distribution of the adult and larval stages of *Thysanoessa* and *Euphausia frigida*, from the N 70 V nets, in the section on the general distribution of these forms, show that in addition to a vertical migration much larger numbers are taken at night than in the daytime. This at first sight would appear to support the theory that they avoid the net during the daytime, but these tables included nets from both shallow- and deep-water stations. Now we have long suspected that at shallow-water stations, i.e. stations of a depth down to 250 or 300 m., the Euphausians may go right down either a very short distance from the bottom or actually resting on the bottom itself during the daytime.

In Tables XL–XLV we give the day and night depth distribution of *Euphausia frigida* larvae and *Thysanoessa* adults, and larvae for the deep-water stations only—i.e. all those of 500 m. depth and over (the numbers of *Euphausia frigida* adults are not shown, being too few to be at all significant). Here we see in each instance, except *Thysanoessa* furcilia, evidence of vertical migration, but the numbers taken at night are *not always* the larger. They are larger in the case of *Thysanoessa*—adults and cyrtopia—almost equal in the case of *Euphausia frigida* furcilia, and smaller in the case of *E. frigida* cyrtopia and *Thysanoessa* furcilia. In no case are the numerical differences of such significance to warrant the suggestion that the organisms are avoiding the net during the daytime.

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[1] This refers to the present report the publication of which has been delayed by additional work in Part V.

[2] The 'B' refers to the 100 cm. diameter net hauled obliquely from 100 m. to the surface.

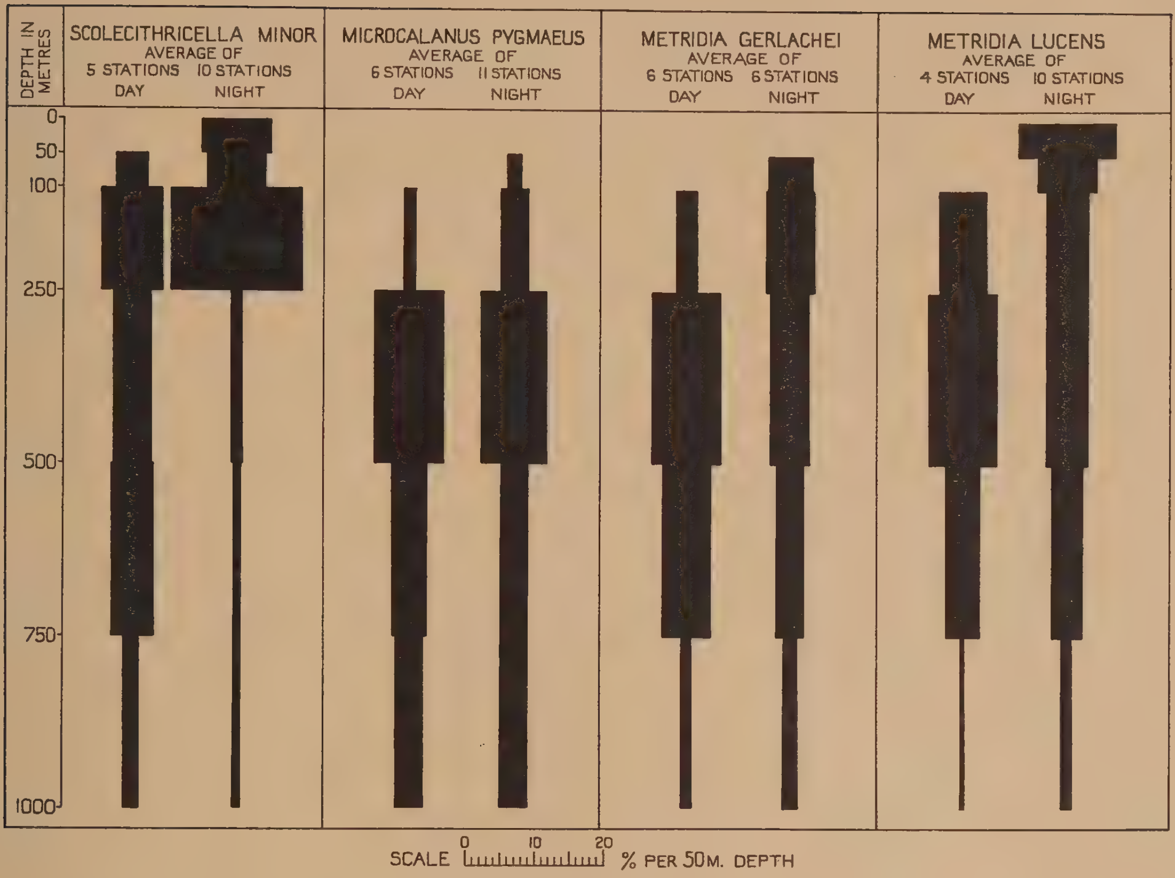

Fig. 115. Chart showing the vertical distribution of four deep-water Copepoda expressed as average percentages per 50 m. haul with the closing N 70 V nets used in a series of six hauls from 1000 m. to the surface (1000–750 m., 750–500 m., 500–250 m., 250–100 m., 100–50 m., and 50–0 m.) at day and night stations.

Table XL

The depth distribution of Euphausia frigida *furcilia as shown by the* N 70 V *nets for stations of* 500 *m. depth and over*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	2	9	11	9	3·6	20
100–50	44	57	11	10	80	114
250–100	73	28	11	10	44·2	18·6
500–250	4	1	11	10	1·4	0·4
750–500	3	0	8	10	1·5	0
1000–750	19	0	7	8	10·9	0
				Totals:	141·6	149·3

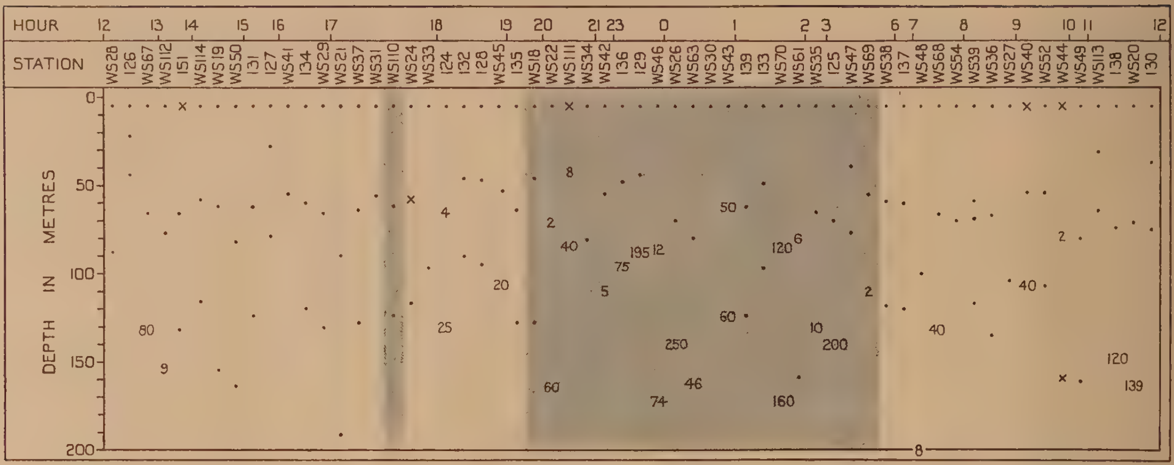

Fig. 116. Chart showing the diurnal depth distribution of *Scolecithricella minor*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

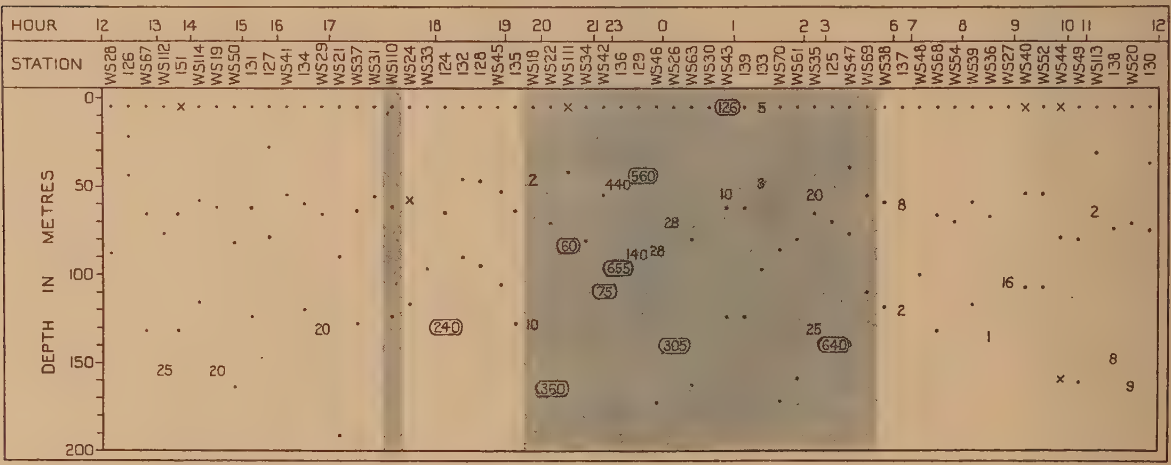

Fig. 117. Chart showing the diurnal depth distribution of *Metridia gerlachei*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

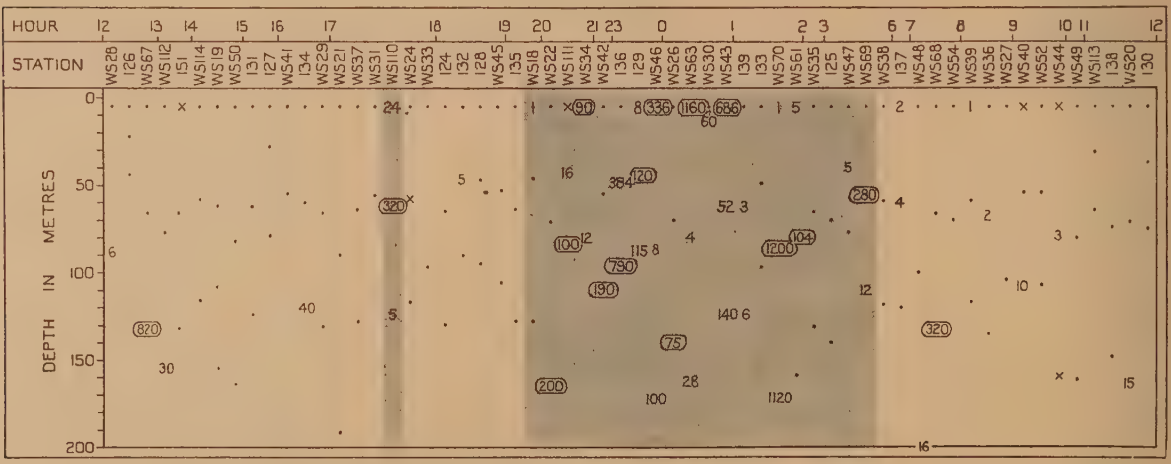

Fig. 118. Chart showing the diurnal depth distribution of *Metridia lucens*. The arrangement of the chart is similar to that described in the legend of Fig. 99.

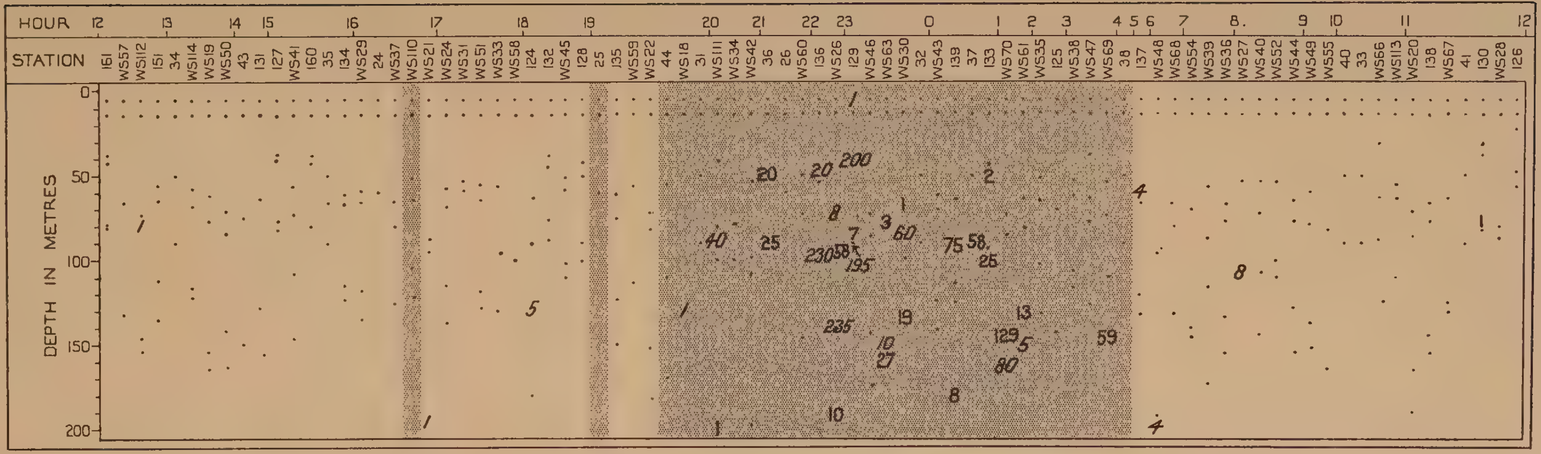

Fig. 119. Chart showing the diurnal depth distribution of *Pleuromamma robusta*. The arrangement of the chart is similar to that described in the legend of Fig. 99, but here the results of both N 100 H and N 70 H nets are combined.

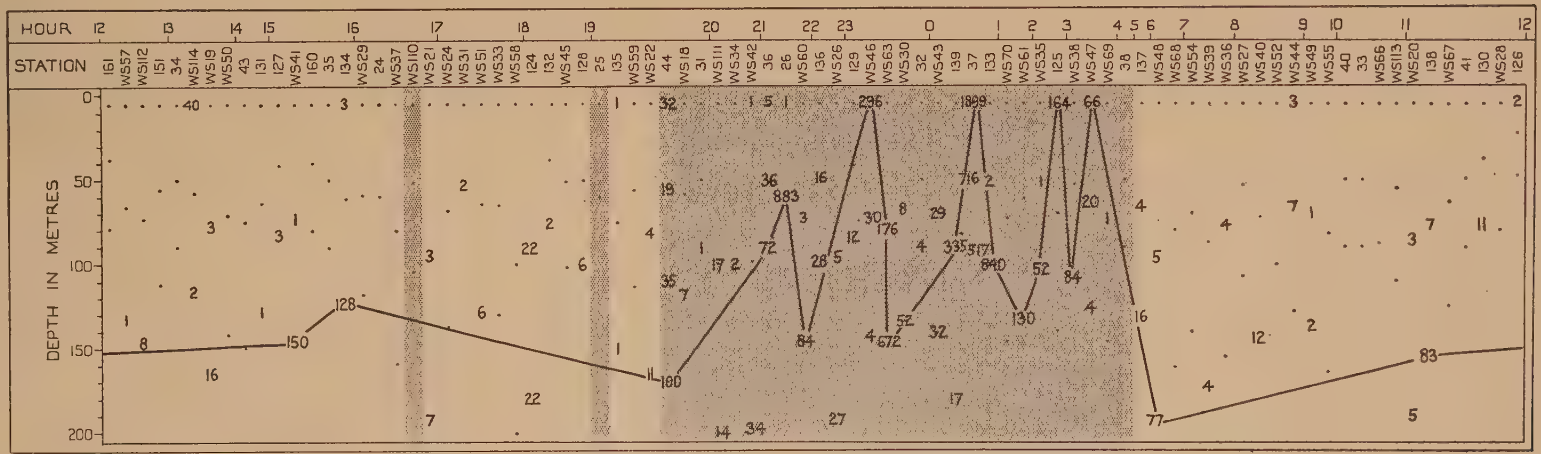

Fig. 120. Chart showing the diurnal depth distribution of *Pareuchaeta antarctica*. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.

Table XLI

The depth distribution of Euphausia frigida *cyrtopia as shown by the N 70 V nets for stations of 500 m. depth and over*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	3	3	11	9	5·4	6·6
100–50	8	9	11	10	14·5	18
250–100	34	4	11	10	20·6	2·7
500–250	21	0	11	10	7·6	0
750–500	0	0	8	10	0	0
1000–750	0	7	7	8	0	3·5
				Totals:	48·1	30·8

Table XLII

The depth distribution of Thysanoessa *spp. furcilia as shown by the N 70 V nets for stations of 500 m. depth and over*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	167	83	14	12	238·6	138·3
100–50	245	129	14	13	350	198·5
250–100	88	66	14	13	42	33·9
500–250	12	0	14	13	3·4	0
750–500	4	0	9	13	1·8	0
1000–750	0	0	8	11	0	0
				Totals:	635·8	370·7

Table XLIII

The depth distribution of Thysanoessa *spp. cyrtopia as shown by the N 70 V nets for stations of 500 m. depth and over*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	84	88	14	12	120	146·6
100–50	65	129	14	13	92·9	193·5
250–100	14	65	14	13	6·7	33·3
500–250	7	1	14	13	2	0·3
750–500	0	6	9	13	0	1·8
1000–750	0	3	8	11	0	1
				Totals:	113·6	381·5

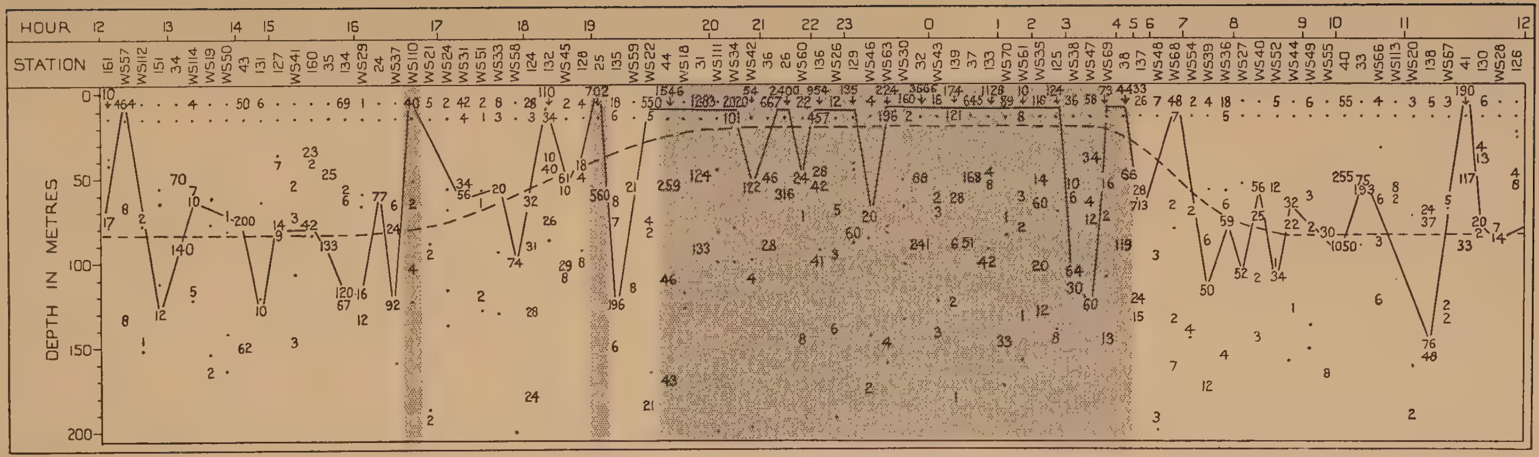

Fig. 121. Chart showing the diurnal depth distribution of *Parathemisto gaudichaudi*. The arrangement of the chart is similar to that described in the legend of Fig. 99, but here the results of both N 100 H and N 70 H nets are combined.

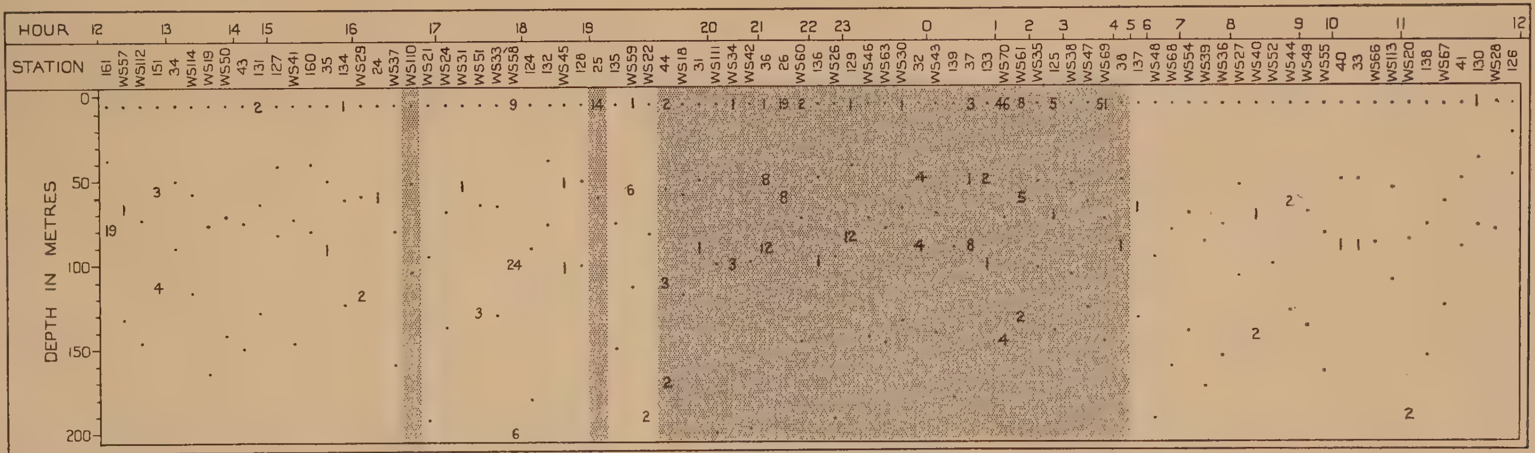

Fig. 122. Chart showing the diurnal depth distribution of *Cyllopus*. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.

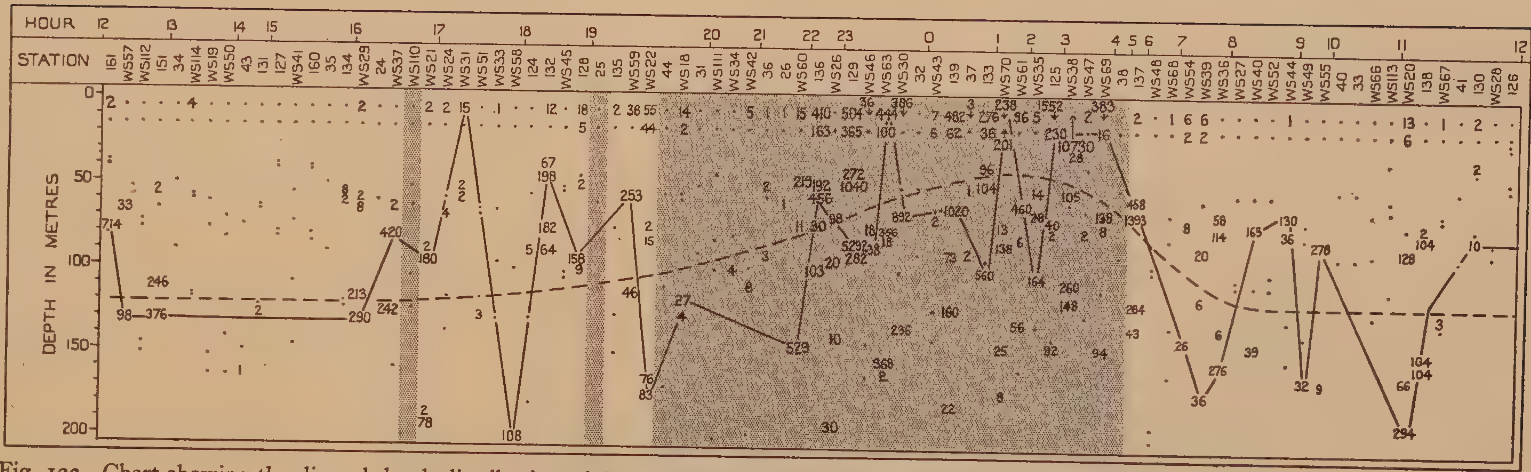

Fig. 123. Chart showing the diurnal depth distribution of *Salpa fusiformis*. The arrangement of the chart is similar to that described in the legend of Fig. 99, but here the results of both N 100 H and N 70 H nets are combined.

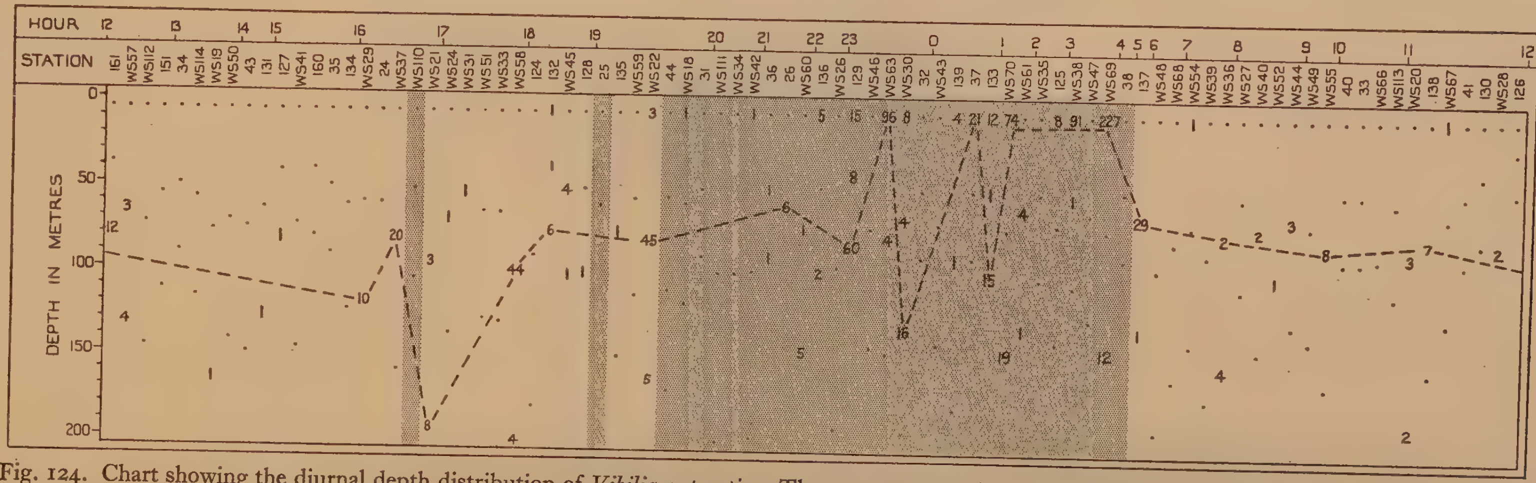

Fig. 124. Chart showing the diurnal depth distribution of *Vibilia antarctica*. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.

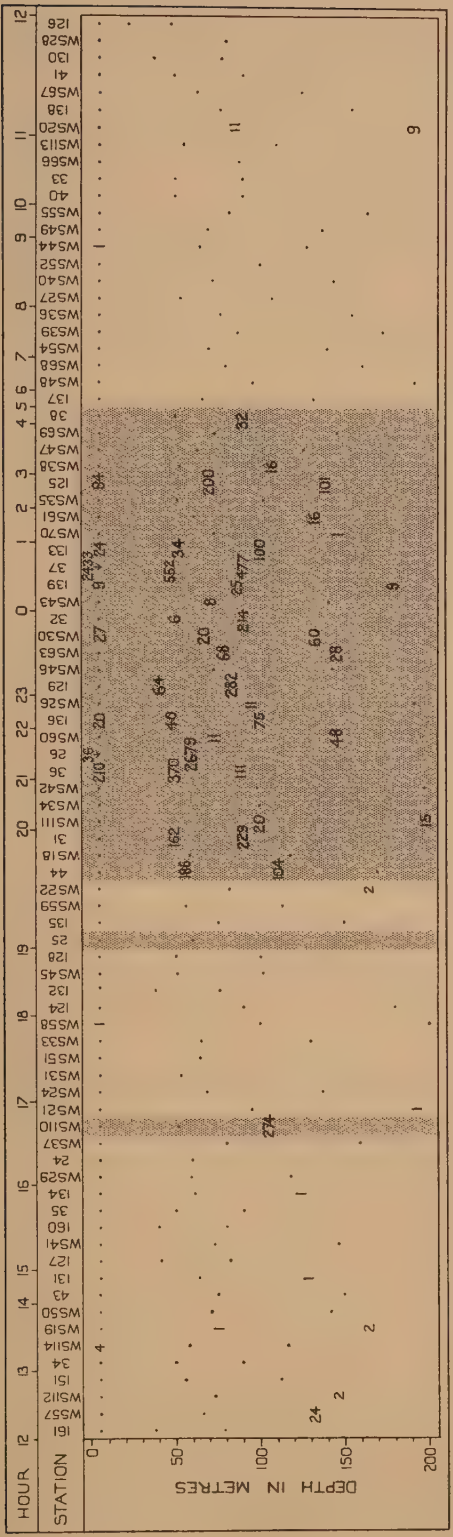

Fig. 125. Chart showing the diurnal depth distribution of *Euphausia frigida*. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.

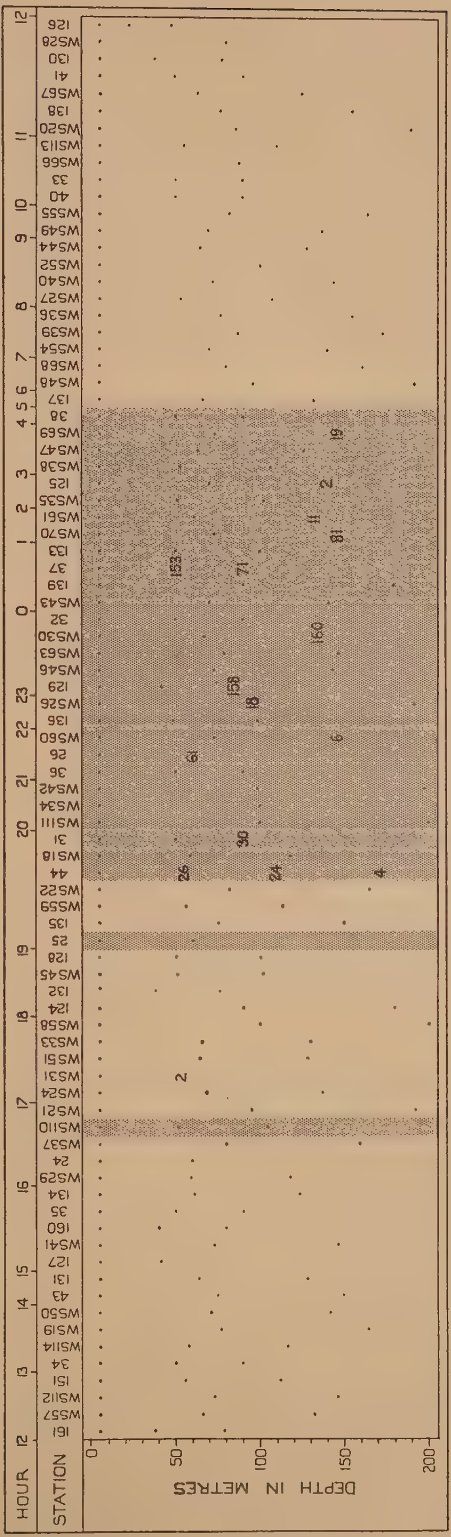

Fig. 126. Chart showing the diurnal depth distribution of *Euphausia triacantha*. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.

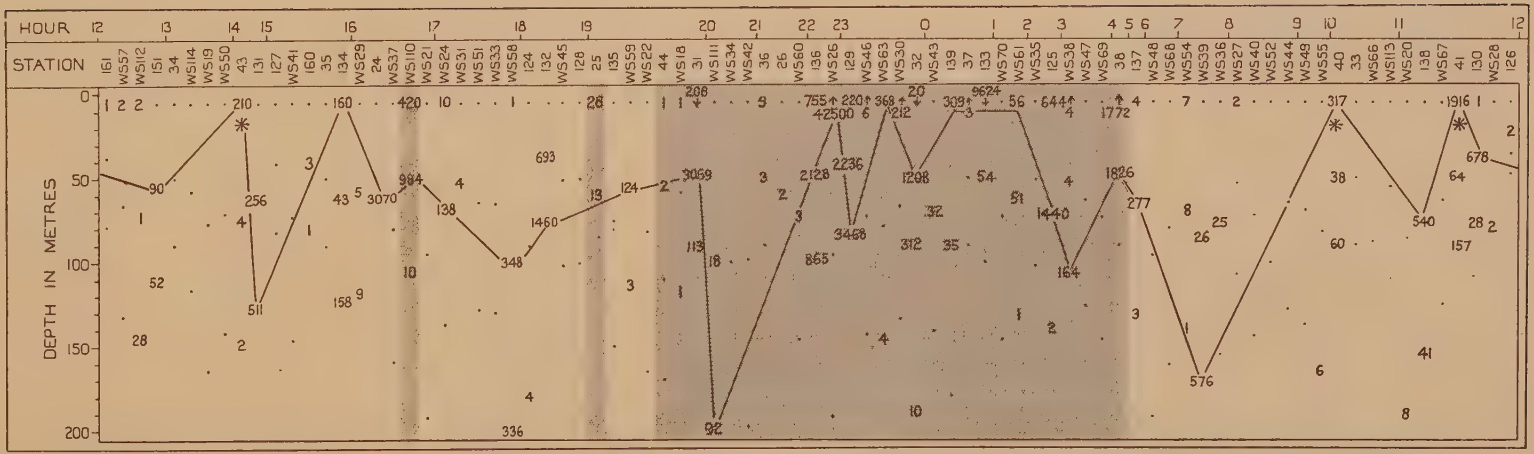

Fig. 127. Chart showing the diurnal depth distribution of *Euphausia superba*. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.* Stations taken in same week at end of March—see text.

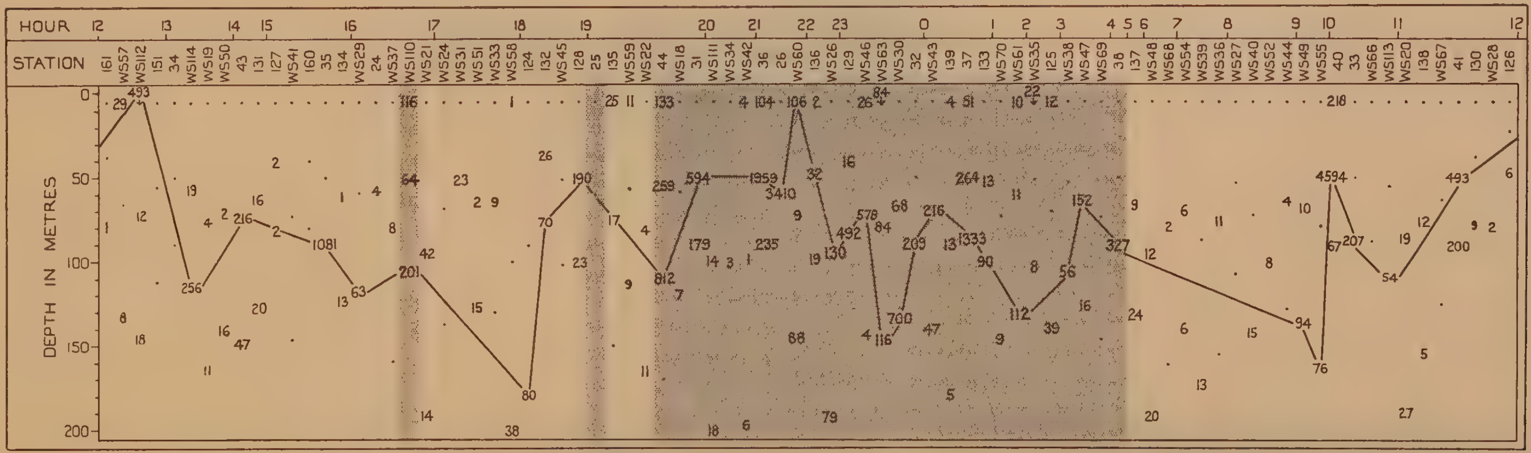

Fig. 128. Chart showing the diurnal depth distribution of *Thysanoessa* spp. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.

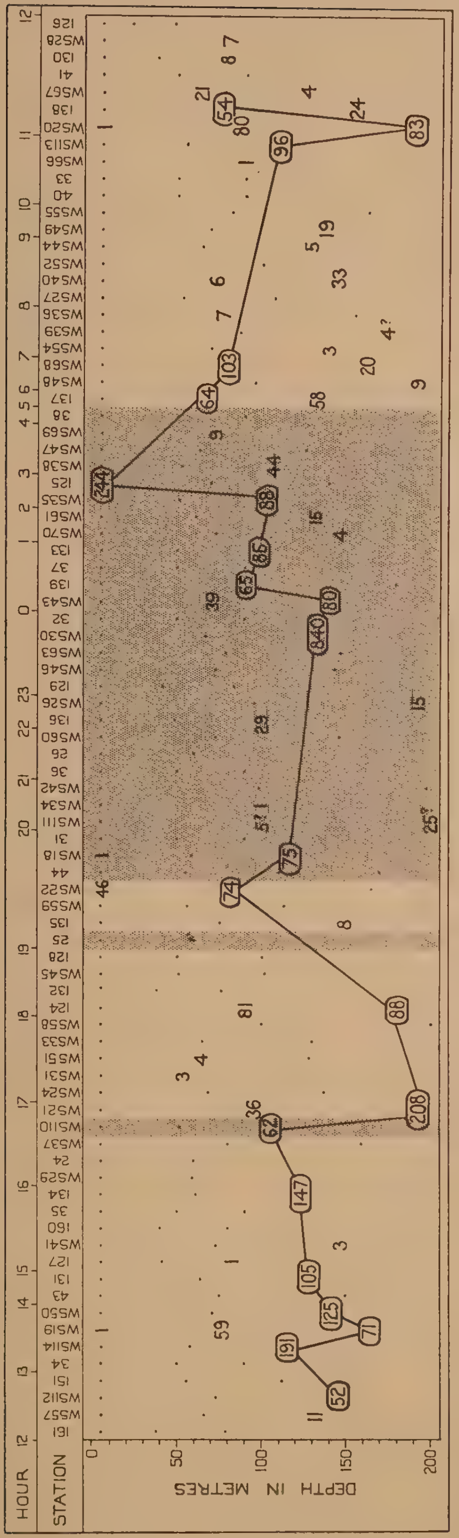

Fig. 129. Chart showing the diurnal depth distribution of *Eukrohnia hamata*. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.

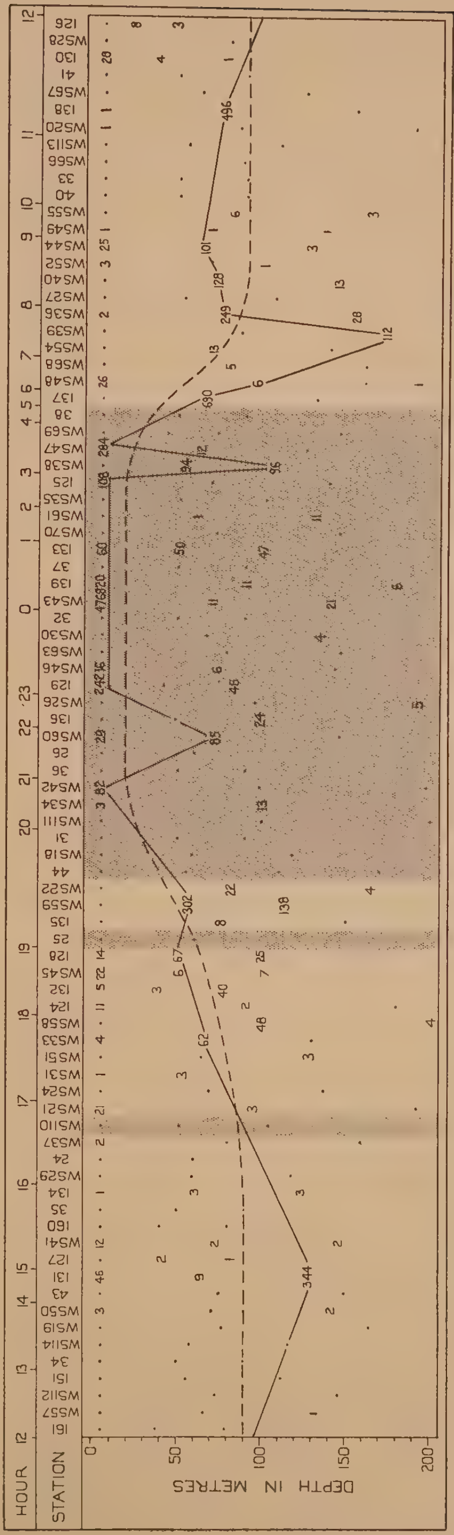

Fig. 130. Chart showing the diurnal depth distribution of *Limacina helicina*. The arrangement of the chart is similar to that described in the legend of Fig. 99 but for N 100 H nets.

Table XLIV

The depth distribution of Thysanoessa vicina, *males, as shown by the N 70 V nets for stations of 500 m. depth and over*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	3	47	14	12	4·3	78·3
100–50	33	23	14	13	47·1	35·4
250–100	4	17	14	13	1·9	8·9
500–250	2	4	14	13	0·6	1·2
750–500	3	0	9	13	1·3	0
1000–750	0	2	8	11	0	0·7
				Totals:	55·2	124·5

Table XLV

The depth distribution of Thysanoessa *spp., females, as shown by the N 70 V nets for stations of 500 m. depth and over*

Depth m.	Total number at each depth		Number of net hauls at each depth		Average number per 1000 m. haul in each range of depth	
	Day	Night	Day	Night	Day	Night
50–0	3	35	14	12	4·3	58·3
100–50	18	19	14	13	25·7	29·2
250–100	15	35	14	13	7·1	16·9
500–250	7	13	14	13	2	4
750–500	7	4	9	13	3·1	1·2
1000–750	2	3	8	11	1	1·1
				Totals:	43·2	110·7

PATCHINESS IN DISTRIBUTION

It is essential to know whether the nets used at any station in a survey give fairly representative samples of the quantities of different organisms in the surrounding waters, or whether the unevenness in the distribution of these organisms may not make the samples unrepresentative. In the present survey we have evidence on this point from two sources: firstly, in regard to the larger forms from two series of consecutive net hauls made with the N 100 H nets at Sts. 150 and WS 53, and secondly, in regard to the smaller forms, by comparing the repeated observations taken at St. 41. The Continuous Plankton Recorder, an instrument partly designed for the purpose of studying the patchiness in the distribution of the plankton, was only in the experimental stages in this commission and was not used in the actual South Georgia survey, so that a discussion of the results obtained with it, having little bearing on this actual survey, will be reserved for a later paper which is in preparation. The results from a single record, however, are shown in Fig. 144. This was taken when approaching South Georgia from the north-east in February 1926, and shows marked patchiness in the distribution of young Euphausians and also a small isolated patch of *Limacina*.

The consecutive net series

On the night of January 11–12, 1927, the 'William Scoresby' took a series of twenty-three consecutive net hauls, each for a half-mile tow, with N 100 H nets from 2130 till 0315 o'clock at a depth of approximately 5 m. below the surface. Two nets, exactly similar to each other in every particular, were employed. The procedure adopted was as follows. The first net was lowered away from the starboard quarter, and towed for half a mile measured by the ship's log, and then hauled in. As this net was being hauled in the second net was lowered away from the port quarter and towed for another half mile. Whilst this second net was being towed the first net was washed down, the bucket emptied and replaced, and the net got ready for reshooting. Then as the second net was hauled in at the end of its half-mile tow the first net was again shot from the starboard quarter. In this manner the series of twenty-three consecutive hauls was obtained using the two nets alternately, so that a continuous sampling was carried out for a distance of 11½ miles. The samples were labelled *A*, *B*, *C*, *D*, etc. to *X* (omitting the use of the letter "*I*" to avoid confusion in labelling with the number "1").

Four nights later, January 15–16, the 'Discovery' at St. 150 took a similar but longer series of fifty consecutive hauls with N 100 H nets covering a distance of just over 30 miles. The procedure was exactly the same as at St. WS 53, but the hauls were of an average 0·6 mile tow (being regulated by timing and not by the log). The samples were labelled *A*, *B*, *C*, *D*, ... , *AA*, *BB*, *CC*, etc. to *AAA*, letters "*I*" and "*II*" being omitted. Samples were not taken at *NN* and *OO* due to the tearing and replacement of one of the nets. The two series were made to the north and north-east of South Georgia, each beginning some 25 miles from the coast; the actual positions may be seen by reference to Fig. 13.

The following organisms were taken in sufficient numbers to enable one to form a good idea of the nature of their distribution: *Beroë*, the Copepods *Calanus propinquus* and *Pareuchaeta antarctica*, the Amphipods *Parathemisto gaudichaudi* and *Vibilia antarctica*, the Euphausiacea *Euphausia superba* and *E. frigida*, and *Salpa fusiformis*. To a lesser extent some evidence regarding the Amphipods *Cyllopus* and *Primno* was obtained.

Whilst *Beroë* did not occur in very large numbers we see from St. WS 53, Fig. 131, that it tends to occur in somewhat denser concentrations of less than half a mile across. In seven consecutive hauls the numbers caught were 2, 18, 7, 31, 1, 41 and 1, whilst a little further in three consecutive hauls we find 2, 19 and 4.

Calanus propinquus, as shown by both series, tends to occur in concentrations some 2 miles across with few or none in between. The series at St. WS 53 showed one such patch and that at St. 150 two such patches separated by only half a mile. The St. WS 53 series showed small numbers for a considerable part of the line sampled, in the St. 150 series it was only taken in small numbers in two samples outside the patches. These patches are shown in Figs. 131 and 132.

Pareuchaeta antarctica is shown by the St. WS 53 series, Fig. 131, to occur irregularly in denser concentrations of at most half a mile or a mile across, and possibly much less.

Parathemisto gaudichaudi was shown to be very patchy in its distribution, particularly in the St. 150 series, where there occurred four very distinct patches, which must have been less than half a mile across. The nature of its distribution can best be shown in graphic form (Fig. 133). The Amphipod *Vibilia antarctica* will be discussed in relation to *Salpa fusiformis*. Small patches of *Cyllopus* and *Primno* are shown in Fig. 132; the distribution of the latter in relation to time of day is interesting in view of Mackintosh's discovery that it apparently makes a vertical migration upwards at daylight; this is discussed on p. 198.

Euphausia superba is shown to be more patchy in its distribution than any of the other forms investigated. In the series at St. 150 seven very dense concentrations occurred, separated by samples of comparatively small numbers. In series St. WS 53 the numbers taken of this species were not so great, and the patchiness, although considerable, was not so marked. The two series are illustrated in Fig. 134. Over part of the St. 150 series it is seen that the samples alternate between ones of very high catch and ones of comparatively low catch, and it might be suggested that this indicates some fault in the catching power of one of the nets, which were used alternatively, but on examining the series further it is at once seen that this is not the cause, since on two occasions the patches elsewhere in the series are separated by two low catches instead of one—i.e. whilst heavy samples *R*, *T*, *V* and *X* are separated by single light samples *S*, *U* and *W*, the heavy samples *O* and *R*, and *X* and *AA* are separated by two light samples *P* and *Q*, and *Y* and *Z*, respectively. The nets were most carefully examined throughout the experiment, and except for the damage and replacement at *NN* were in perfect order and of exactly similar catching power.

From the fact that there is usually such a sharp contrast between a heavy sample and light samples taken on either side of it, it would appear that the size of the patches of *E. superba* must be considerably less across than the length of the tow of the net, otherwise one would expect to find such patches more frequently being sampled by two adjacent net hauls instead of one. Only in the case of nets *AA* and *BB* may two nets have sampled the same dense patch.[1]

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[1] If we had a large number of observations it should be possible to calculate the approximate size of the patches, or rather to say that they should not be greater than a certain size, assuming the patches to be circular in shape. Professor G. C. Steward has kindly given us the following expression for such a problem:

$$n = \frac{\pi a}{2b} - N,$$

where n is the number of patches which extend across a division between two net hauls, N is the total number of patches observed, a is the radius of the patch which is assumed to be circular, and b the length of tow of each net haul. Now unfortunately the number of observations we are dealing with in the present instance is far too small to place any great reliance upon the result of such a calculation, but it does give one a provisional and very approximate idea of their size. Thus in St. 150 there are seven dense concentrations, one of which falls across two nets (*AA* and *BB*) and the length of tow is 0·6 mile, so that the radius of a patch is approximately not greater than 96 yards, or a patch say is not more than 200 yards across. Now it is possible that one or more of these half-mile samples may have cut across more than one patch—for example, net *O*

On p. 210 we have described a dense patch of young *E. superba* only a few feet across observed in one of the fjords. The habit that this *Euphausia* has of occurring in these dense swarms helps one to understand how it is that the great rorquals—the Blue and Fin whales—are able to take in sufficient nourishment from the plankton to maintain their huge bodies. The patchiness of this organism has again been frequently demonstrated by the fact that at the same station the N 100 H net near the surface or at some lower depth may have caught very few, whereas the N 70 H net following it at the same depth may have caught a great many and vice versa.

E. frigida was only taken in considerable numbers in series St. WS 53, and here only one not very dense patch was recorded (Fig. 131). Whilst specimens were taken over a continuous length of 2 miles the concentration was only over half a mile of this length. It suggests that this species too is essentially patchy in its distribution.

Salpa fusiformis var. *aspera* also shows marked patchiness, but here the size of the patches would seem to be much larger. Series 150 shows one very dense patch of three miles across, and three other patches of much smaller numbers also of two or three miles across; series WS 53 stopped perhaps in the middle of a large patch. The irregular distribution of this form is shown in Fig. 135 together with that of the Amphipod *Vibilia*. We have already discussed on p. 199 a suspected ecological link between these two forms, and it is significant that in each case the patches of *Vibilia* correspond with those of *Salpa* in position and approximately in proportionate numbers. This is perhaps the strongest piece of evidence in support of this association.

In each of the charts illustrating the consecutive net series a scale of time is also given. The fact that the patches of *Euphausia superba* end at 0100 o'clock must not be taken to mean that there were definitely no more such patches beyond this point—there may have been patches below the line of tow of the nets which were not lower than 5 m. depth. The series of patches may indicate the upper limit of vertical migration like the crest of a wave coming into the line of observation between 1830 and 0100 o'clock, but being below it before and sinking below it again after these times. This conception is illustrated in the diagram in Fig. 136. In each series, Sts. 150 and WS 53, we see the big patch of Salps occurring at approximately 0300 o'clock and smaller patches earlier. In Fig. 123, showing the vertical migration of Salps, we saw that they tended to come up towards the surface late in the night, so that the small patches sampled on the

caught nearly twice as much as each of the nets *G*, *T* and *V*. Thus if we count net *O* as two patches the calculated width of a patch becomes approximately 170 yards. This of course is only a possibility, since we must only occasionally cut across the diameter of a patch—more often than not we cut an arc across it—and net *O* may represent the only patch we have cut at the diameter; and again we must not assume that all the patches are the same size. The small samples between two large samples may well represent arcs cut through large patches lying to right or left of the track of the ship. All we are attempting to do here is to indicate that whilst the patches may be very much smaller as far as our evidence goes it is likely that they are *not larger* than some 200 yards across. Again they may not be circular patches at all but possibly long bands of plankton cut transversely by the path of the ship; a possible mode of formation of such bands is discussed in Part V on p. 353. If they are indeed bands it is likely that they would have a width not greater than that estimated for the diameter of the supposed circular patches.

lines before 0300 o'clock may represent the upper edges of larger swarms below not yet risen into the line of observation. Similarly, in this species we may be observing patches at the top of a wave of vertical migration.

Station 41. Here we have evidence of patchiness regarding some of the smaller organisms obtained in quite a different way.

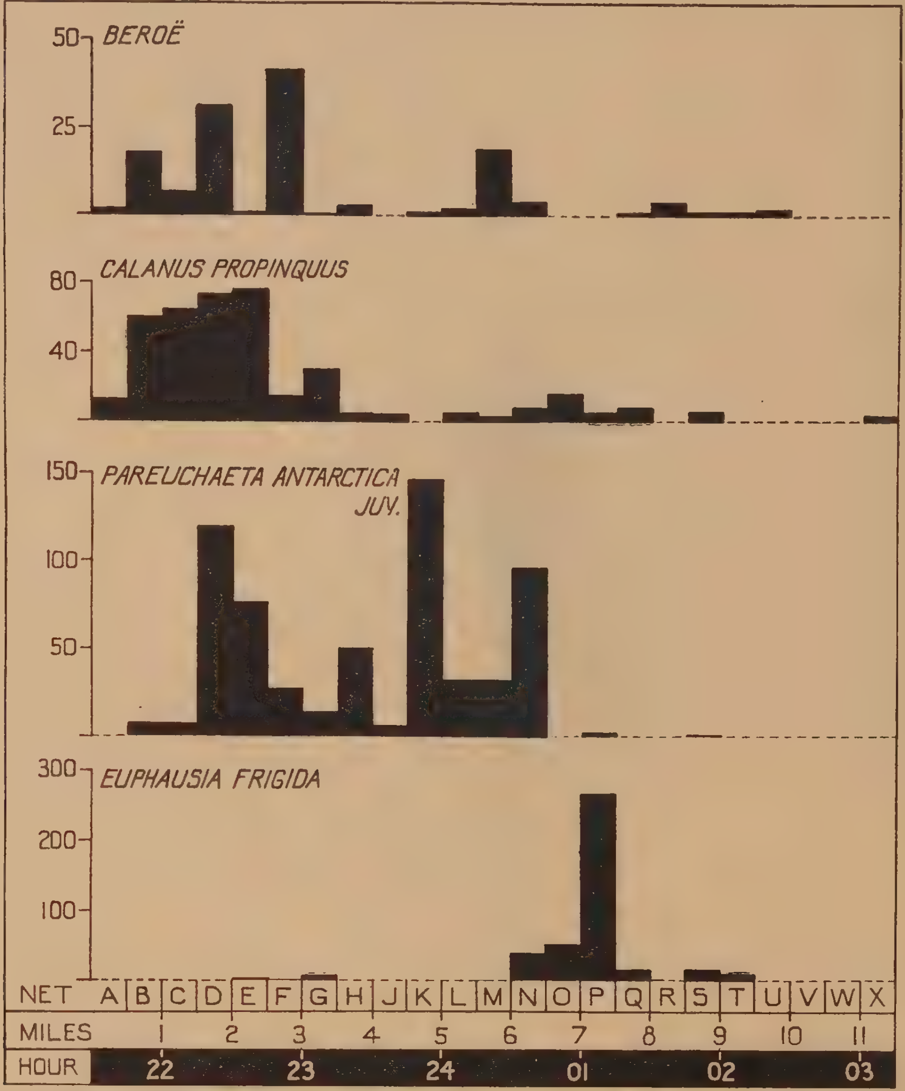

Fig. 131. Histogram showing the variations in the numbers of several plankton animals taken in twenty-three consecutive surface hauls with N 100 H nets (*A–X*) at St. WS 53.

As has already been explained in the earlier section on vertical migration, the 'Discovery' anchored in 272 m. of water at St. 41, 16 miles off the north-east coast of South Georgia, in an attempt to carry out repeated observations on the plankton throughout a period of 24 hours. The object of this experiment was primarily to study the vertical migration of the plankton, but also to obtain a series of observations which would to

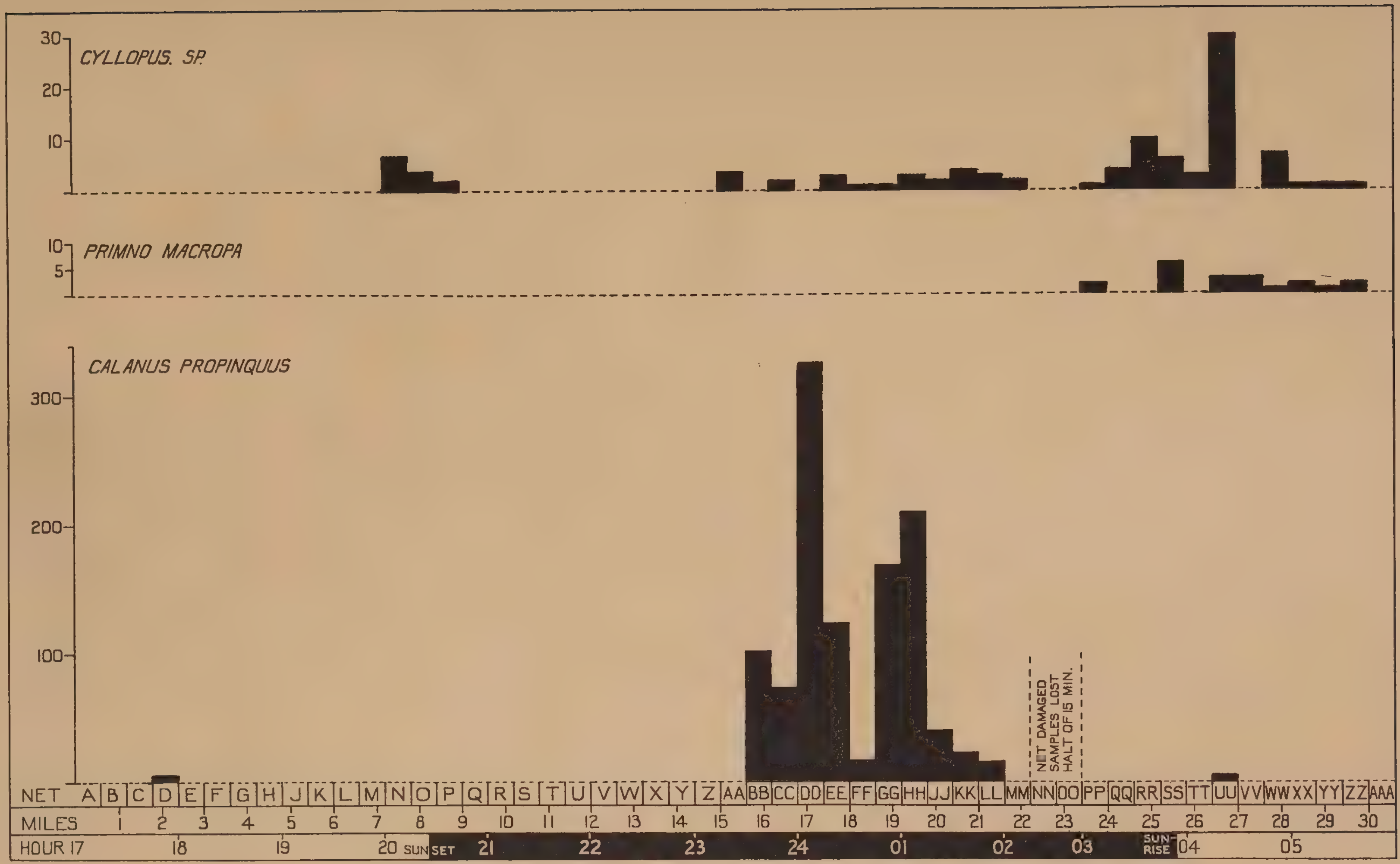

Fig. 132. Histogram showing the variations in the numbers of three plankton animals taken in forty-nine consecutive surface hauls with N 100 H nets (*A–AAA*) at St. 150.

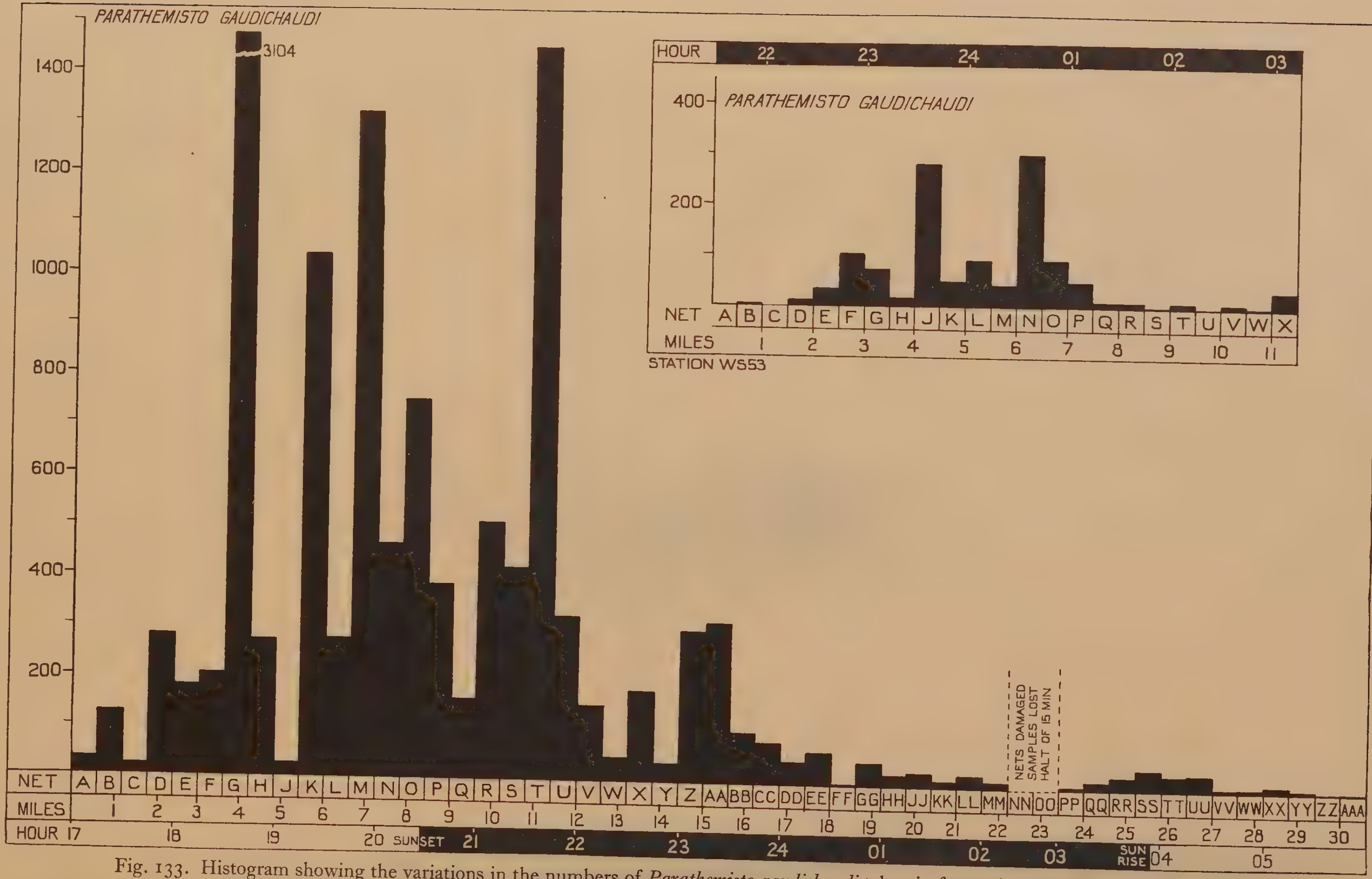

Fig. 133. Histogram showing the variations in the numbers of *Parathemisto gaudichaudi* taken in forty-nine consecutive surface hauls with N 100 H nets (*A–AAA*) at St. 150 and (inset) in twenty-three similar hauls (*A–X*) at St. WS 53.

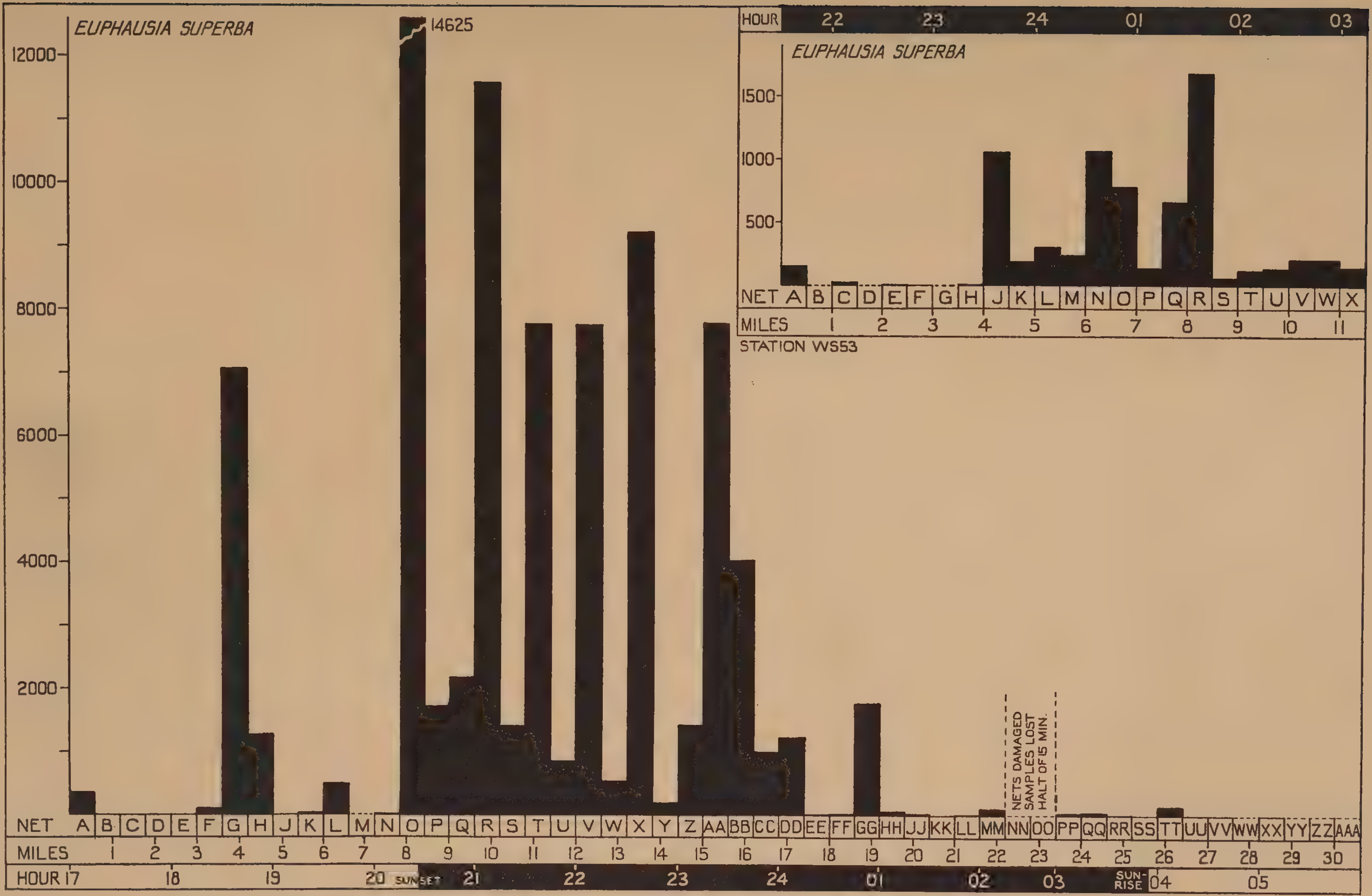

Fig. 134. Histogram showing the variations in the numbers of *Euphausia superba* taken in forty-nine consecutive surface hauls with N 100 H nets (*A–AAA*) at St. 150 and (inset) in twenty-three similar hauls (*A–X*) at St. WS 53.

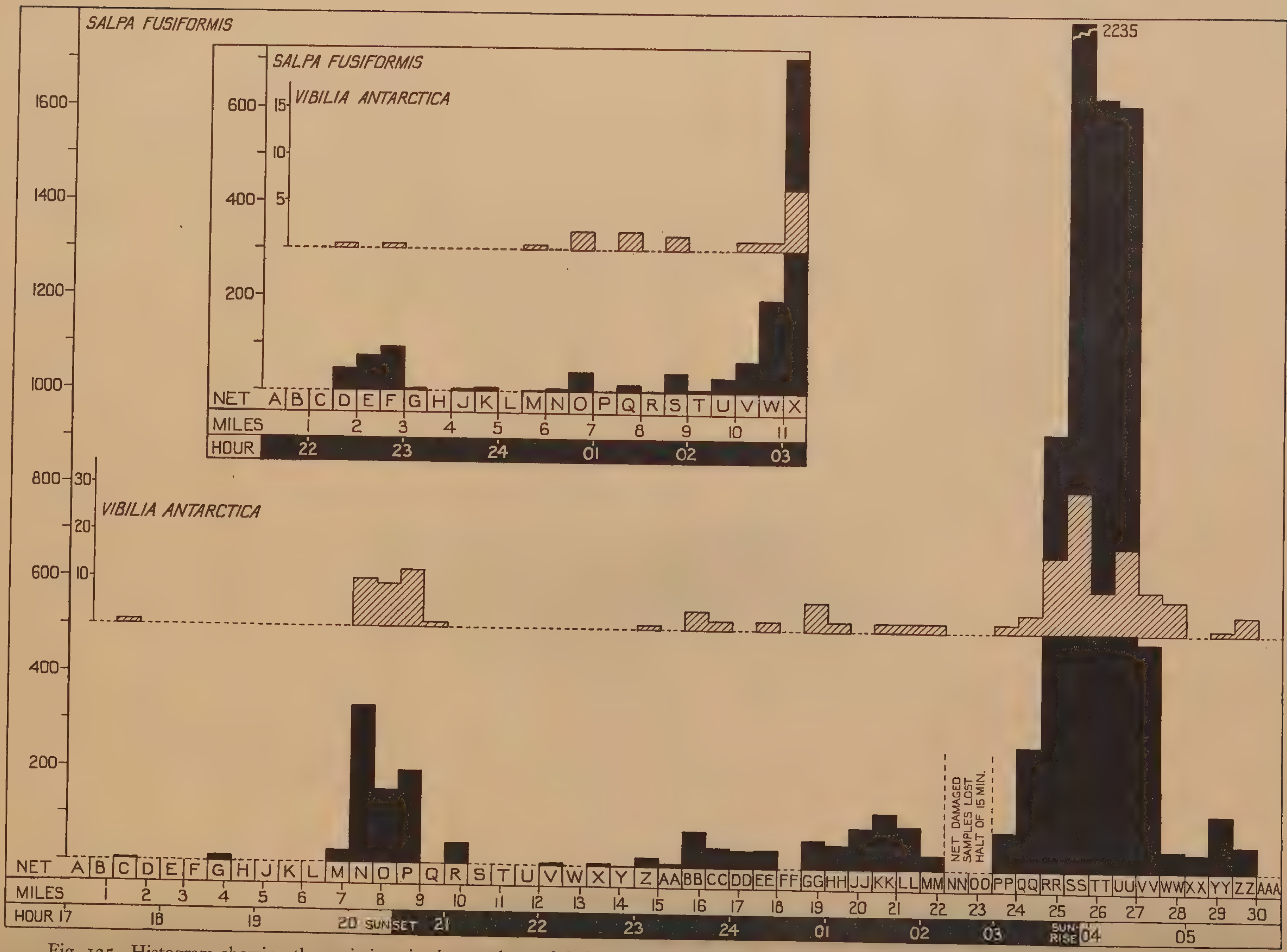

Fig. 135. Histogram showing the variations in the numbers of *Salpa fusiformis* and the amphipod *Vibilia antarctica* taken in forty-nine consecutive surface hauls with N 100 H nets (*A–AAA*) at St. 150 and (inset) in twenty-three similar hauls (*A–X*) at St. WS 53. Note the apparent association between the two species.

some extent serve as a "control" experiment in relation to the single hauls at isolated stations. Vertical hauls with the N 70 V closing net were made from the bottom to the top in the following series: 265–150 m., 150–100 m., 100–50 m. and 50 m. to the surface, and whilst the experiment could not be continued as planned for the whole 24 hours due to an oncoming gale, the series was repeated five times during a period of 8 hours at 1300, 1540, 1700, 1910 and 2105 o'clock respectively. We shall consider the differences in the total numbers of the different organisms taken in the whole vertical column from the bottom to the top, so that these differences will be quite independent of changes due to the vertical migration (unless some organisms are actually resting for part of the time on or within a few feet of the bottom). We shall express the total numbers as numbers per 50 m. haul, so that they will be comparable with the similar numbers we have used for the different organisms in charting their distribution in the upper 250 m. round South Georgia.

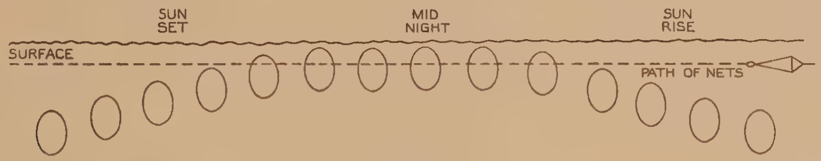

Fig. 136.

Since the nets used for each series were exactly the same and used in exactly the same way, the differences in the numbers recorded are due either to the working error in the laboratory analysis or to actual differences in the concentrations sampled by the net, i.e. to unevenness in distribution of the species concerned in the water drifting past the ship at anchor. The range of the error in laboratory analysis has already been determined and discussed on pp. 30–38, so that the unevenness in distribution of a particular species may be gauged by the extent to which the range of difference in numbers found exceeds the determined range of error in laboratory methods.

The results obtained are shown in Table XLVI.

Four species *Ctenocalanus vanus*, *Drepanopus pectinatus*, *Oithona frigida* and *Oncea notopus* show a range of variation in numbers far exceeding the range of laboratory error, and may be said to display distinct patchiness within a small area, i.e. the area of drift past the ship between 1300 and 2105 o'clock. The degree of patchiness of these four species is shown in Figs. 137–140, where the excess of variation in numbers over the possible range due to laboratory error is shown.

We have already seen from the consecutive net series that *Calanus propinquus* tends to occur in much larger patches, so that we should not expect a marked patchiness in a small area as sampled at St. 41. A general idea of the larger patchiness of various species may be gained by the study of the vertical distribution figures for the South Georgia survey December-January 1926–7. *Scolecithricella minor*, which is all but absent from St. 41, shows a marked patchiness when the line of five stations 13–17, taken at ten-mile intervals off the north-east coast of South Georgia in March 1926, is considered. The average number per 50 m. haul for the top 250 m., taken at these stations in order from 13 to 17, is as follows: 7, 324, 5, 0 and 434.

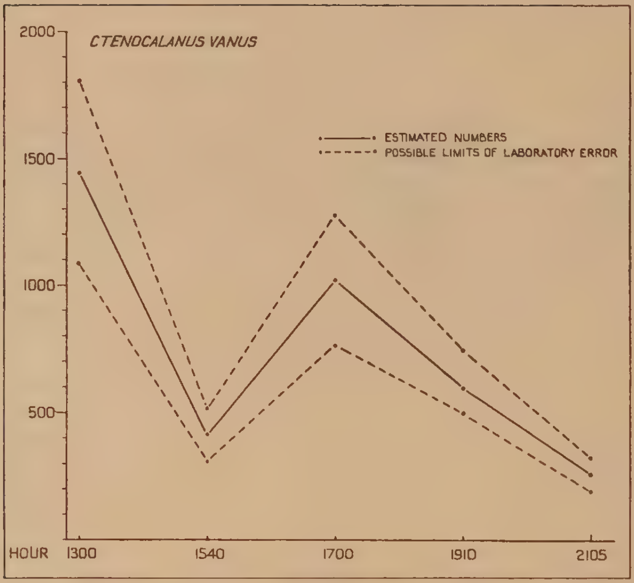

Fig. 137. Graph showing the variations in the estimated numbers of *Ctenocalanus vanus* (expressed as an average per 50 m. haul) taken in the columns of water from the bottom (265 m.) to the surface by N 70 V nets at five different times at St. 41.

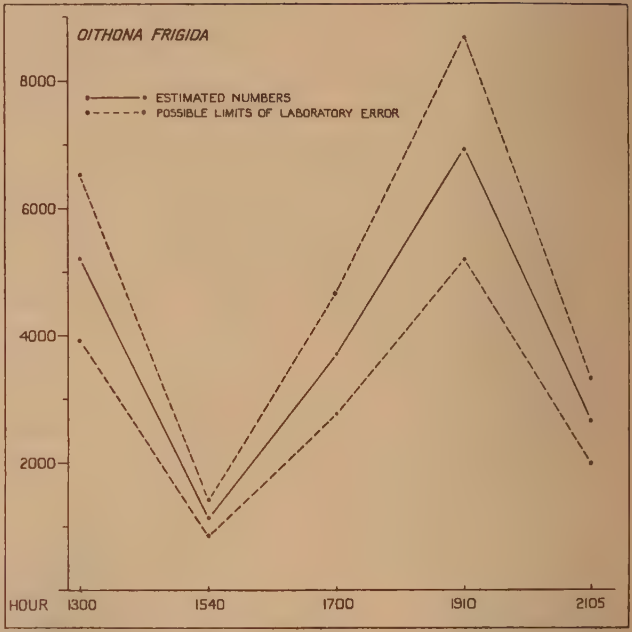

Fig. 139. Graph showing the variations in the estimated numbers of *Oithona frigida* (expressed as an average per 50 m. haul) taken in the columns of water from the bottom (265 m.) to the surface by N 70 V nets at five different times at St. 41.

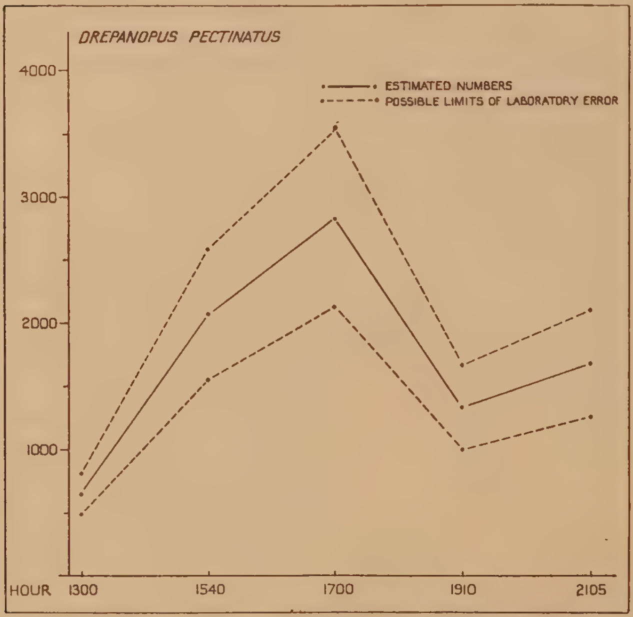

Fig. 138. Graph showing the variations in the estimated numbers of *Drepanopus pectinatus* (expressed as an average per 50 m. haul) taken in the columns of water from the bottom (265 m.) to the surface by N 70 V nets at five different times at St. 41.

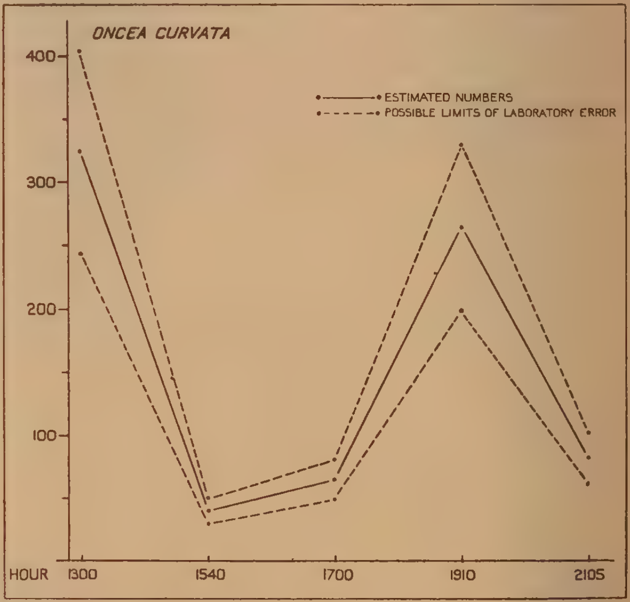

Fig. 140. Graph showing the variations in the estimated numbers of *Oncea curvata* (expressed as an average per 50 m. haul) taken in the columns of water from the bottom (265 m.) to the surface by N 70 V nets at five different times at St. 41.

Table XLVI

The numbers per 50 m. haul of fourteen different organisms taken by N 70 V nets from a column of water from the bottom to the surface at five different times at St. 41

Hour	*A*	*B*	*C*	*D*	*E*	Average
	1300	1540	1700	1910	2105	
Pelagobia, ad. and juv.	2	16	10	34	9	14
Eukrohnia hamata	10	0	8	15	6	8
Calanus simillimus	3	5	4	3	1	3
C. propinquus	118	108	104	56	104	98
C. acutus	296	238	154	126	156	194
Rhincalanus gigas	50	14	27	35	27	31
Ctenocalanus vanus	1445	415	1021	599	260	748
Drepanopus pectinatus	651	2072	2832	1332	1678	1713
Pareuchaeta antarctica	5	3	1	2	4	3
Scolecithricella minor	0	0	0	0	9	2
Metridia lucens	530	241	206	549	216	348
Oithona frigida	5228	1138	3719	6947	2678	3942
Oncea curvata	324	40	65	264	82	155
Limacina balea	3	9	1	8	0	4

SEASONAL CHANGES IN THE ZOOPLANKTON

As with the phytoplankton, little can be said to advantage regarding the seasonal changes in the zooplankton from the material of the present survey; it is only when these results are embodied with those of later surveys that a knowledge of these changes will be obtained. At present we have a series of stations taken over the same area, the line running at right angles to the north-east coast of South Georgia, in four different months: November, December, March and May. We must not consider the other stations taken in December over a wider area to the north and south, or those taken in January which were nearly all on the western side of the island, for all these are in areas of different water mixtures. Then again, whilst the observations taken in November, December and May were all in the same Antarctic season of 1926–7, those taken in March were in the previous season 1925–6. It is obviously not satisfactory to include the March of one season with other months of another season in considering the seasonal changes, especially as we shall see in Part V how the conditions of one season may vary from another.

Bearing in mind these limitations to our material we can make a few observations regarding the commoner forms. These in general, as would be expected, show an increase in animal numbers with the advance of the Antarctic spring and a decline at the approach of winter. Tables XLVIII and XLIX show the temperature changes at different times of the year at positions approximately 15 and 45 miles off the north-east coast of South Georgia. The Foraminifera and Radiolaria are well represented in November and December, but very few occur in March and May. *Eukrohnia hamata*, the only Chaetognath occurring in sufficient numbers to warrant consideration regarding seasonal change, shows a very even numerical strength in these four months November to May.

The Copepoda, with the exception of *Metridia lucens* which shows little or no decline in May and appears to be an autumnal form, all show an increase with the advance of summer and decline in the late autumn, just as they do in the northern hemisphere. In Table XLVII the average numbers of the commoner Copepoda per 50 m. in the upper 250 m. are shown for these four months.

Table XLVII

The average number of the commoner Copepoda per 50 m. haul with the N 70 V net in the top 250 m. off the north-east coast of South Georgia in November, December and May, 1926–7 season, and in March 1925–6 season

	November 1926	December 1926	March 1926	May 1927
Calanus propinquus	5	105	143	69
Calanus acutus	64	112	232	5
Rhincalanus gigas	18	57	71	20
Ctenocalanus vanus	310	194	1069	175
Drepanopus pectinatus	298	477	1681	0
Metridia lucens	0	14	202	198
Oithona frigida	1426	1954	3933	2619

Table XLVIII

Showing the temperature in ° C. at stations taken at different times of the year at approximately the same position 15 miles off the north-east coast of South Georgia

Season ...	November 27 (1926)	December 20 (1926)	March 3 (1926)	March 28 (1926)	May 28 (1927)
Station ...	WS 19	131	14	41 A	WS 114
Depth (m.)					
0	0·2	1·95	3·01	2·43	0·90
5	0·2	1·85	3·01	2·42	—
10	0·2	1·72	3·00	2·42	0·90
20	0·2	1·22	3·00	2·41	0·90
30	0·1	1·01	2·96	2·40	0·90
40	0·1	0·94	2·96	2·31	0·90
50	0·1	0·88	2·90	2·27	0·91
60	—	0·50	—	—	0·93
75	−0·6	—	1·04	2·22	—
80	—	−0·65	—	—	1·06
100	−0·9	−0·63	0·67	1·22	1·04
150	—	−0·28	0·72	0·80	1·15
200	—	0·12	1·12	1·42	—
250	—	0·81*	1·62	1·72	—

* Depth 240 m.

Very few of the Amphipod *Parathemisto gaudichaudi* were taken in November and May, but they were abundant in December and particularly in March. Very few of the Euphausiacea, *Euphausia frigida*, *E. superba*, and *Thysanoessa*, were taken in November, but each were either fairly well represented or abundant in December, March and also in May. We have already noted that Rustad and Wheeler have demonstrated that *Euphausia superba* lives for two years, and Clark (1919) has shown how abundant it may be in the Antarctic winter. In view of the small number of stations taken in November little significance should be attached to this month's results unless confirmed by later work.

Reference has already been made on pp. 203 and 214 to the different stages in the development of Euphausian larvae in different seasons.

Limacina helicina, as far as our observations go, would appear to be an early summer form, being abundant in December but absent in March and May with only a few taken in November, and *L. balea* an autumnal form which was only present in fair numbers in May, being absent in November, December and March. *Salpa fusiformis* was abundant in November and December, but poorly represented in March and May.

Table XLIX

Showing the temperature in ° C. at stations taken at different times of the year at approximately the same position 45 miles off the north-east coast of South Georgia (except St. 151 which is 60 miles off the coast)

Season ...	November 30 (1926)	December 22 (1926)	January 16 (1927)	March 4 (1926)	May 26 (1927)
Station ...	WS 22	139	151	17	WS 111
Depth (m.)					
0	0·1	1·01	1·31	2·62	0·46
5	0·1	—	—	2·62	—
10	0·1	1·01	1·20	2·62	0·45
20	0·00	1·00	0·92	2·62	0·46
30	0·05	0·72	0·81	2·62	0·47
40	−0·1	0·13	0·76	2·57	0·47
50	−0·1	0·00	0·60	2·42	0·47
60	—	−0·12	0·48	—	0·48
75	−0·15	—	—	1·53	—
80	—	−0·34	0·26	—	0·48
100	−0·65	−0·22	−0·50	−0·18	0·47
150	−0·3	0·20	−0·20	0·77	0·20
200	0·6	0·45	0·85	1·44	1·02
300	1·9	1·42	1·60	1·94	1·40
400	2·2	1·74	1·80	2·09	1·89
500	1·94	—	—	2·07	1·76
600	—	1·99	1·87	—	—
750	1·82	—	—	—	1·65
800	—	1·90	1·73	—	—
1000	1·14	—	1·52	1·78	1·52

PLANKTON AND ROUGH WEATHER

The force of the sea was recorded at every station in terms of Beaufort's scale. It has often been supposed that plankton organisms tend to sink from the surface layers during stormy weather. Our results do not confirm this supposition. In Table L the results of all the surface hauls made with N 100 H nets have been collected in two series for day and night under headings of Force of Sea, 0–2, 3–4 and 5–7. The actual numbers of the more important organisms taken in the individual nets are recorded, together with the average number per net according to each state of sea. These average figures really mean little or nothing on account of the tendency of masses of the organisms to occur in swarms. A general view should be taken of the actual numbers recorded, and allowance made for the number of nets taken in each state of sea.

The inequality in the number of stations in each state of sea must be kept in mind. For the three states of sea employed in the table there are respectively 27, 18 and 12 stations in daylight and 8, 11 and 12 stations at night. Since the organisms occur in swarms, the larger the number of stations considered the greater are the chances of meeting with a big swarm. *Parathemisto gaudichaudi* illustrates this. The actual number of hauls in which it was captured in the daytime in the three states of sea were 16, 11 and 6, which are approximately proportional to the number of stations: 27, 18 and 12. Only one really big swarm was taken, 464, and this falls in the first category where 27 hauls were made.

It will be seen that whilst there is a slight tendency for lesser numbers of some organisms to be taken in the rougher seas during the daytime this is not so at night, and we must come to the conclusion that the state of the sea has little or no bearing on the number of organisms in the surface layers.

We have already remarked (p. 11) upon the violence of the sudden storms which are of frequent occurrence in these regions. It might be thought that the water over the continental shelf would in consequence be churned up to such an extent that the vertical distribution of the plankton would be so disturbed as often to render an account of it of little value. We have, however, ample evidence to show that this is not so. At St. 41 we have observed the vertical distribution of a number of species at more or less two-hourly intervals; for example, we have seen the marked migration of *Calanus simillimus* and *Drepanopus pectinatus*, Figs. 101 and 102, and lack of migration in *Calanus acutus* and *Rhincalanus gigas*, Figs. 111 and 112. Now in the charts illustrating vertical distribution combining the N 70 H results for *all stations*, whether taken in fair weather or rough, or after rough weather, we see that these species show equally well the types of vertical distribution they showed at St. 41, see Figs. 99, 100, 108 and 109. Had rough weather been an important factor influencing the vertical distribution these charts would not have revealed these clear-cut differences in behaviour. Nor can the instances of apparently less regular behaviour, such as that of *Calanus propinquus*, Fig. 103, be due to such a cause, for the stations and net hauls are the same as those in the other figures just

Table L

Showing the numbers of the more important plankton animals taken in the surface N 100 H nets in different states of sea, separated into day and night stations

	Day					
	Force of sea 0–2		Force of sea 3–4		Force of sea 5–7	
	Actual numbers taken in individual surface nets from 27 stations	Av. per net	Actual numbers taken in individual surface nets from 18 stations	Av. per net	Actual numbers taken in individual surface nets from 12 stations	Av. per net
Beroë	36	1·3	20	1·1	9	0·8
Eukrohnia hamata	46, 21	2·5			1, 1, 1	0·25
Calanus simillimus	13, 3, 1	6·3	2, 6, 2, 1, 1, 2, 17	1·7	3, 1, 9, 3	1·3
C. propinquus	3, 46, 352, 22, 19, 5, 12, 76, 16, 2, 6, 17, 7, 5, 21, 89, 1	26·1	138, 301, 2, 19, 26, 2, 1, 43, 140, 13, 1, 27, 38	25·6	160, 55, 2, 28, 2, 10, 164	35·1
C. acutus	8, 1, 1, 4, 11, 1, 5	1·2	1, 43, 18, 1, 1	3·5	133, 3, 56, 1, 6, 22	18·6
Rhincalanus gigas	6, 2, 1	0·3	2, 4, 2, 1	0·5	2	0·2
Pareuchaeta antarctica	1, 2, 3	0·2	3, 10	0·7		
Parathemisto gaudichaudi	4, 26, 5, 2, 4, 55, 190, 18, 1, 464, 8, 1, 6, 69, 10, 1	32·0	3, 5, 5, 4, 5, 3, 36, 50, 6, 34, 4	8·6	3, 3, 5, 7, 6, 7	2·6
Vibilia antarctica	3, 1	0·1	1, 1	0·1	1	0·1
Euphausia frigida	8	0·3	1, 1	0·1		
E. superba	4, 13, 10, 317, 116, 35, 2, 7, 9, 1, 1, 160, 1	10·2	2, 210	11·8	3, 3, 1	0·6
Thysanoessa spp.	218, 880, 29, 1	41·6	1, 493, 52, 67	34·1	2	0·2
Limacina helicina	14, 1, 2, 12, 28, 1	2·1	11, 1, 21, 25, 22, 3, 3, 46, 5	7·6	1, 2, 26, 1	2·5
Salpa fusiformis	2, 55, 2, 15, 2, 6, 1, 2	3·1	2, 1, 38, 1, 12, 4	3·2	13, 2, 1	1·3
TOTAL		127·3		98·6		63·5

	Night					
	Force of sea 0–2		Force of sea 3–4		Force of sea 5–7	
	Actual numbers taken in individual surface nets from 8 stations	Av. per net	Actual numbers taken in individual surface nets from 11 stations	Av. per net	Actual numbers taken in individual surface nets from 12 stations	Av. per net
Beroë	0	0	34	3·1	36, 200, 15	21·8
Eukrohnia hamata	4	0·5	244	22·2		
Calanus simillimus	44, 2, 1, 18, 7, 2	9·2	6, 18, 2	2·4	11, 7	1·5
C. propinquus	48, 151, 474, 194, 2032, 122	377·6	114, 35, 1664, 180, 9, 126	193·5	1, 83, 16, 12, 75, 140, 135	36·9
C. acutus	22, 3	3·1	17, 7, 110, 33	15·2	23, 10, 12	3·8
Rhincalanus gigas	1	0·1	257, 1	14·4	88, 2	7·5
Pareuchaeta antarctica			4, 41, 296, 30, 14, 42	39·1	5696, 1, 12	475·8
Parathemisto gaudichaudi	135, 2, 8, 457, 36, 22, 192	105·2	13, 300, 19, 124, 16, 4, 58, 73, 89, 2000, 2000	1610·3	1775, 4000, 3850, 1936, 54, 6, 1128, 121, 40, 11000, 106, 136	2012·7
Vibilia antarctica	15, 8, 5, 91, 16	15·6	10, 8, 227, 74	29	64, 1, 1, 12, 4	6·8
Euphausia frigida	27, 20	5·9	84, 631, 3904	419·9	63, 7309, 48, 7	618·9
E. superba	386, 212, 56, 755, 1, 92, 42500	5500·2	5316, 908, 16, 24, 49, 9, 1	574·8	28, 623, 3, 9600, 307, 420, 61	920·2
Thysanoessa spp.	2, 1	0·4	1, 12, 6, 2, 12, 313, 173	47·2	62, 152, 3, 520, 4, 116, 22	74·3
Limacina helicina	242, 386, 163, 7	74·8	108, 4768, 16, 284	470·5	82, 60, 20, 3, 15	15
Salpa fusiformis	365, 96, 10730, 15, 444	206·2	78, 1552, 7, 36, 2, 383, 201	203·5	2, 8, 5, 276, 482, 5	64·8
TOTAL		6298·8		3645·1		4260·0

Table LI

For explanation see text (page 268)

Age of the moon in days ...	1–2		3–4		5–6		7–8		9–10		11–12		13–14	
Day or night stations ...	D.	N.	D.	N.	D.	N.	D.	N.	D.	N.	D.	N.	D.	N.
Number of nets	4	4	—	6	24	18	17	3	7	—	—	1	16	6
Calanus propinquus	148	792	—	432	2086♀	12♀ 136 j.	12♀ 312 j.	180♀	—	—	—	—	250	1♂ 113♀
	—	2476	—	480	1080♀	956♀	—	180	—	—	—	—	136♀	519♀
	—	—	—	252	126 j. 10♀	128♀	—	—	—	—	—	—	2♂ 159♀	—
	—	—	—	2♂ 11♀ 214 j.	184♀	16♂ 320♀	—	—	—	—	—	—	—	—
	—	—	—	—	—	123♀	—	—	—	—	—	—	—	—
	—	—	—	—	—	1664♀	—	—	—	—	—	—	—	—
	—	—	—	—	—	369♀	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	347	1775	—	3850	580	2000	—	—	—	—	—	—	191	124
	179	1400	—	372	227	163	—	—	—	—	—	—	1050	—
	—	4000	—	400	210	118	—	—	—	—	—	—	190	—
	—	694	—	11000	420	1936	—	—	—	—	—	—	117	—
	—	—	—	264	400	505	—	—	—	—	—	—	—	—
	—	—	—	722	—	152	—	—	—	—	—	—	—	—
	—	—	—	—	—	13300	—	—	—	—	—	—	—	—
	—	—	—	—	—	200	—	—	—	—	—	—	—	—
	—	—	—	—	—	359	—	—	—	—	—	—	—	—
Euphausia frigida	—	778♂ 3687♀	—	202♂ 284♀	—	169♂ 462♀	—	—	—	—	—	—	—	200
	—	—	—	211♂ 475♀	—	528♂ 582♀	—	—	—	—	—	—	—	101
	—	—	—	301♂ 342♀	—	91♂ 243♀	—	—	—	—	—	—	—	96♂ 98♀
	—	—	—	—	—	1903♂ 5406♀	—	—	—	—	—	—	—	—
	—	—	—	—	—	552♂ 1104♀	—	—	—	—	—	—	—	—
	—	—	—	—	—	237♂ 1194♀	—	—	—	—	—	—	—	—
Euphausia superba	322?	—	—	623	179 j	5316	—	—	—	—	—	—	317	182♂ 454♀ 272 j
	3070	—	—	3069	70♂ 68♀	5400	—	—	—	—	—	—	116	1440
	—	—	—	113	—	—	—	—	—	—	—	—	38♂ 51♀	42500
	—	—	—	1208	—	—	—	—	—	—	—	—	175 j.	—
	—	—	—	313	—	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	3206 j.	—	—	780	—	208	500 j.	152	—	—	—	—	218	55♂ 75♀
	—	—	—	—	—	—	—	—	—	—	—	—	6528 j.	—
	—	—	—	—	—	—	—	—	—	—	—	—	880 j.	—
Limacina helicina	—	—	—	—	128	4768	—	284	—	—	—	—	—	108
	—	—	—	—	101	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	154	—	—	—	186 118 j.	—	—	—	714	1552
	—	—	—	—	126	—	—	—	—	—	—	—	232	—

Table LI (*cont.*)

Age of the moon in days ...	15–16		17–18		19–20		21–22		23–24		25–26		27–28	
Day or night stations	D.	N.	D.	N.	D.	N.	D.	N.	D.	N.	D.	N.	D.	N.
Number of nets	37	15	22	17	16	—	9	3	6	6	14	—	—	—
Calanus propinquus	1♂ 200♀ 299♀ 1♂ 288♀ 19♀ 169 j. 348♀ 205♀ 231♀ —	4♂ 152♀ 1♂ 363♀ 151♀ 1151 j. 81♀ 8♀ 156 j. 628♀ 22♀ 452 j. 16♀ 1♂ 141 j.	220♀ 2♂ 100♀ 3♂ 184♀ 173♀ 9♂ 125♀ 497 j. 1♂ 445♀ —	2♂ 192♀ 325♀ 135♀ 117 j. 48♀ 122 j. 2♀ 110 j. — —	126♀ 300 4♀ 316 j. — — — — —	— — — — — — — —	1♂ 119♀ 164♀ 154♀ 104♀ — — — —	— — — — — — — —	160♀ 117♀ 2♂ 202♀ 3♂ 271♀ 210♀ — — —	— — — — — — — —	140 352 — — — — — —	— — — — — — — —	— — — — — — — —	— — — — — — — —
Parathemisto gaudichaudi	464 — — — —	135 1128 — — —	107 606 j. — — — —	457 106 136 121 192	200 2000 337 — —	— — — — —	— — — — —	— — — — —	— — — — —	— — — — —	— — — — —	— — — — —	— — — — —	— — — — —
Euphausia frigida	— — — —	252 — — —	— — — —	— — — —	3904 242 2750 j. 50♂ 85♀ 88♂ 124♀	— — — —	— — — —	— — — —	— — — —	105♂ 169♀ — — —	— — — —	— — — —	— — — —	— — — —
Euphausia superba	55♂ 82♀ 111♂ 237♀ 144♂ 192♀ 43♂ 81♀ 217♂ 387♀ 128♂ 128♀ 163♂ 306♀ 323♂ 370♀ 482♂ 934♀	116♂ 104♀ 166 j. 1252♂ 984♀ 2448♂ 1020♀ 432 j. 148♂ 64♀ 6396♂ 3204♀ — — — —	69♂ 91♀ 36♂ 104♀ 139♂ 138♀ 189♂ 351♀ — — — — —	179♂ 380♀ 196 j. 976♂ 1152♀ 372♂ 493♀ 208♂ 99♀ 128♂ 240♀ 72♂ 68♀ — — —	232♂ 139♀ 365 j. 210 — — — — — — —	— — — — — — — — —	— — — — — — — — —	— — — — — — — — —	— — — — — — — — —	195♂ 225♀ 444♂ 540♀ — — — — — — —	— — — — — — — — —	— — — — — — — — —	— — — — — — — — —	— — — — — — — — —
Thysanoessa spp.	190 — —	492 70♂ 105♀ 280♂ 420♀	— — —	— — —	16♂ 234♀ — —	— — —	131 j. — —	450 j. — —	— — —	39♂ 77♀ 48♂ 153♀ —	— — —	— — —	— — —	— — —
Limacina helicina	302 138 344	242 — —	690 496 249	— — —	109 — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — —
Salpa fusiformis	213 1544 108 225 182 — — — — — —	126 j. 239 272 5292 372 892 236 482 276 104 560 460	1340 104 114 276 420 — — — — — —	118 j. 45 192 164 149 j. 333 10730 105 440 356 352 — —	— — — — — — — — — — —	— — — — — — — — — — —	210 j. — — — — — — — — — —	248 135 j. — — — — — — — — — —	108 367 180 — — — — — — — —	— — — — — — — — — — —	103 — — — — — — — — — —	— — — — — — — — — — —	— — — — — — — — — — —	— — — — — — — — — — —

referred to; any disturbance of the water must affect them all alike. Again the hydrological data, Figs. 7 and 8, do not support the conception of marked vertical disturbances being brought about by violent gales.

A CONSIDERATION OF THE POSSIBILITY OF A LUNAR INFLUENCE UPON THE PLANKTON

It is known that the moon has a marked influence on the breeding of certain marine animals governing the period at which the dehiscence of eggs and sperm takes place, so that the two are liberated at the same time. Worms of the genus *Leodice* and certain Echinids are examples of organisms influenced in this way by phases of the moon.[1] It occurred to us that the swarming of planktonic organisms might take place under the same influence. We have not sufficient evidence from our present survey to come to any conclusion in the matter, but we have thought it worth while to tabulate our results, so that later workers can refer to them and combine our insufficient material with later observations, and thus in time provide a body of evidence which will decide whether or no any such influence is at work. In Table LI we have set out the age of the moon in 2-day periods and below tabulated all the occurrences of the organisms which occur in large numbers in the N 100 H nets.[2] Only those occurrences when their numbers exceed 100 are shown. There are periods for which very little or no information is available. The samples are taken from all over the survey, and thus in one phase of the moon more may be taken in one area than in another, *so that any apparent correlation of numbers with phases of the moon is likely to be due to differences in regional distribution rather than to the effect of lunar periodicity*. On the other hand, it is just possible that the reverse is in fact the case, and that our idea of distribution is upset by the influence of the moon upon swarming. We see in this particular set of observations that larger numbers of *Euphausia superba*, *Thysanoessa* spp. and *Salpa fusiformis* are taken round about the period of the full moon rather than at other times, and in the case of *Parathemisto gaudichaudi* and *Euphausia frigida* more are taken at the first quarter than at other times, with a slight indication that they are taken in larger numbers again at the last quarter. *Calanus propinquus* shows no such apparent periodicity.

These results are put forward with the utmost reserve and diffidence. It must be understood that no significance is intended to be attached at present to the lunar correlations here suggested: the figures are provided solely for the convenient reference of future workers who may be able to add further data.

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[1] Since this was written Savage and Hodgson (1934) have described the influence of the moon on the shoaling of the East Anglian herring.

[2] All N 100 H nets, i.e. not only surface nets, are used for this, since presumably swarms, if any, formed under lunar influence would not disperse in diurnal migration.

PART V. THE PLANKTON COMMUNITY, THE WHALE FISHERIES, AND THE HYPOTHESIS OF ANIMAL EXCLUSION

By A. C. Hardy, M.A.[1]

PLANKTON AND WHALE DISTRIBUTION

One of the objects in undertaking these investigations was an attempt to obtain a better understanding of the natural history of the great plankton-feeding rorquals —the Blue and Fin whales. We have seen that they have been shown by Mackintosh and Wheeler (1929) and others to feed in this area exclusively upon the one species of Euphausian, *E. superba*. It is important to know how closely the distribution of these whales is correlated with that of their food supply. Naturally some correlation with the distribution of their food is to be expected; but if the whales are not continually feeding, there may be other important factors governing their movements. The degree of correlation between the distribution of the whales and Euphausians should give some measure of the relative importance of food as compared with that of other factors which are as yet unknown. A very close correlation over a number of seasons would indicate the pre-eminent importance of the plankton as a factor determining the location of the fisheries.

Recently Kemp and Bennett (1932) have published a report on the distribution of the Blue and Fin whales at South Georgia and the South Shetlands based on returns sent in by the industry on forms specially provided. They chart the monthly distribution of whales taken in the South Georgia fisheries for the seasons 1923–4 to 1930–1, and the South Shetlands fishery for the seasons 1922–3 to 1928–9. They have kindly allowed us in this section to reproduce a number of their charts. In Fig. 141 are shown the distribution of Fin and Blue whales round South Georgia in December 1926, together with the distribution of *E. superba* during the plankton survey in the latter half of December and early January. It is seen that the correlation with both species of whale is a fairly close one.

Since the whaling stations and floating factories were all situated in the fjords of the north-east coast one might expect the majority of whales to be taken in the region close to these stations if they were at all evenly distributed round the island, and this might give rise to an apparent but false correlation, but a reference to Fig. 142 will show that the whales are not always taken off this coast, and at times the whalers have to go far from the stations in search of them.

Fig. 143 shows the distribution of Blue and Fin whales in March 1926. They are concentrated in a small area against the coast quite different from their distribution in December 1926. In March 1926 we began our plankton investigations in the area. As already explained, it was impossible owing to the lateness of the season and a succession of gales to survey more than a limited region off this coast, but as far as it went this survey showed that the *E. superba* were also concentrated at this time close against the

[1] I am indebted to the many friends with whom I have discussed the arguments put forward in this section, particularly to my colleague Mr E. R. Gunther who wishes it to be known that he is in complete agreement with the conclusions that I have reached.

coast, very few being taken at the outlying stations. This is also shown in Fig. 143. In the December–January survey they were met with farther out, and on the evidence available comparatively few were against the coast.

We had felt some doubt regarding the validity of our estimation of the *E. superba* distribution, since there is a tendency for more of them to be taken in the nets at night stations owing to their vertical migration at dusk into the upper layers. This factor, as explained on p. 211, does not appear to be so important in the consideration of *E. superba* as it does in that of *E. frigida*, since *superba* does not make anything like so extensive a vertical migration as does *frigida*. We have, however, set out the stations in March and early April 1926 in two groups in the list below, those within 25 miles of the coast and those farther out, and we have put in heavy type the stations taken in the hours of darkness and the numbers of *E. superba* taken at those stations. This clearly shows that the distribution here is quite independent of the distribution of the night stations.

Inner stations

St. 23	0
St. 24	3,070
St. **25**	**48**
St. **31**	**3,805**
St. **32**	**1,582**
St. **38**	**10,716**
St. 40	415
St. 41	1,980
St. 43	216

Outer stations

St. **26**	**2**
St. 33	0
St. 34	0
St. 35	0
St. **36**	**12**
St. **37**	**3**
St. 44	3

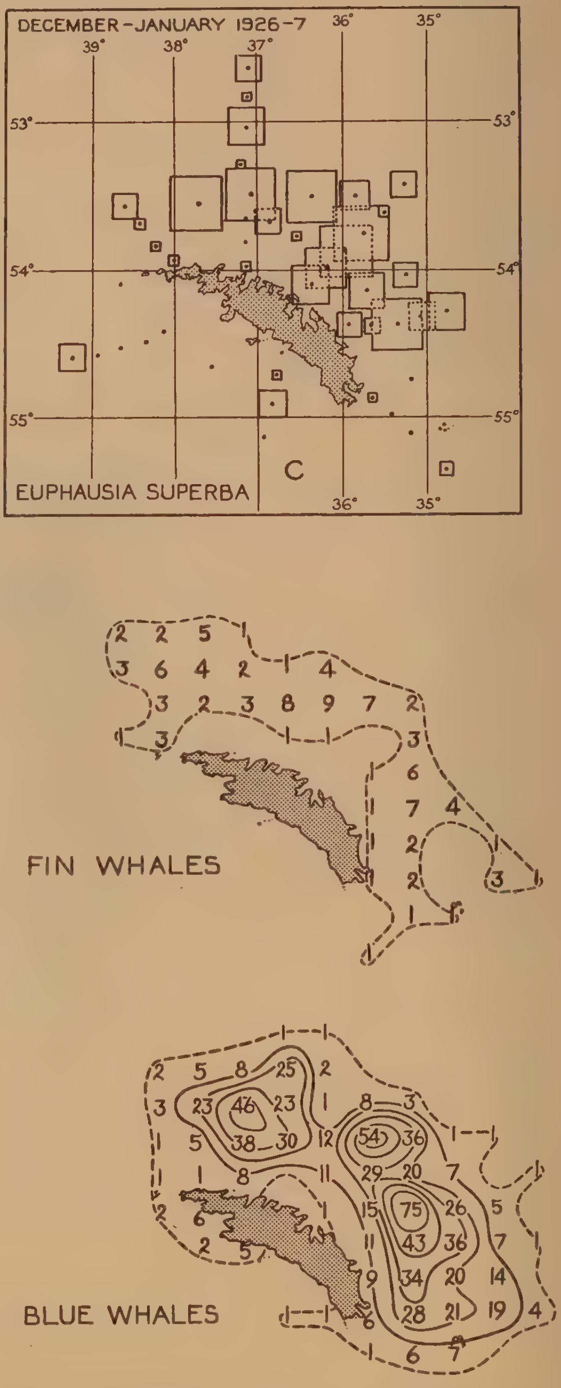

Fig. 141. *Euphausia superba* and whale distribution in December 1926 (whale distribution from Kemp and Bennett, 1932).

Mackintosh and Wheeler (1929, p. 363) in their report on the Blue and Fin whales

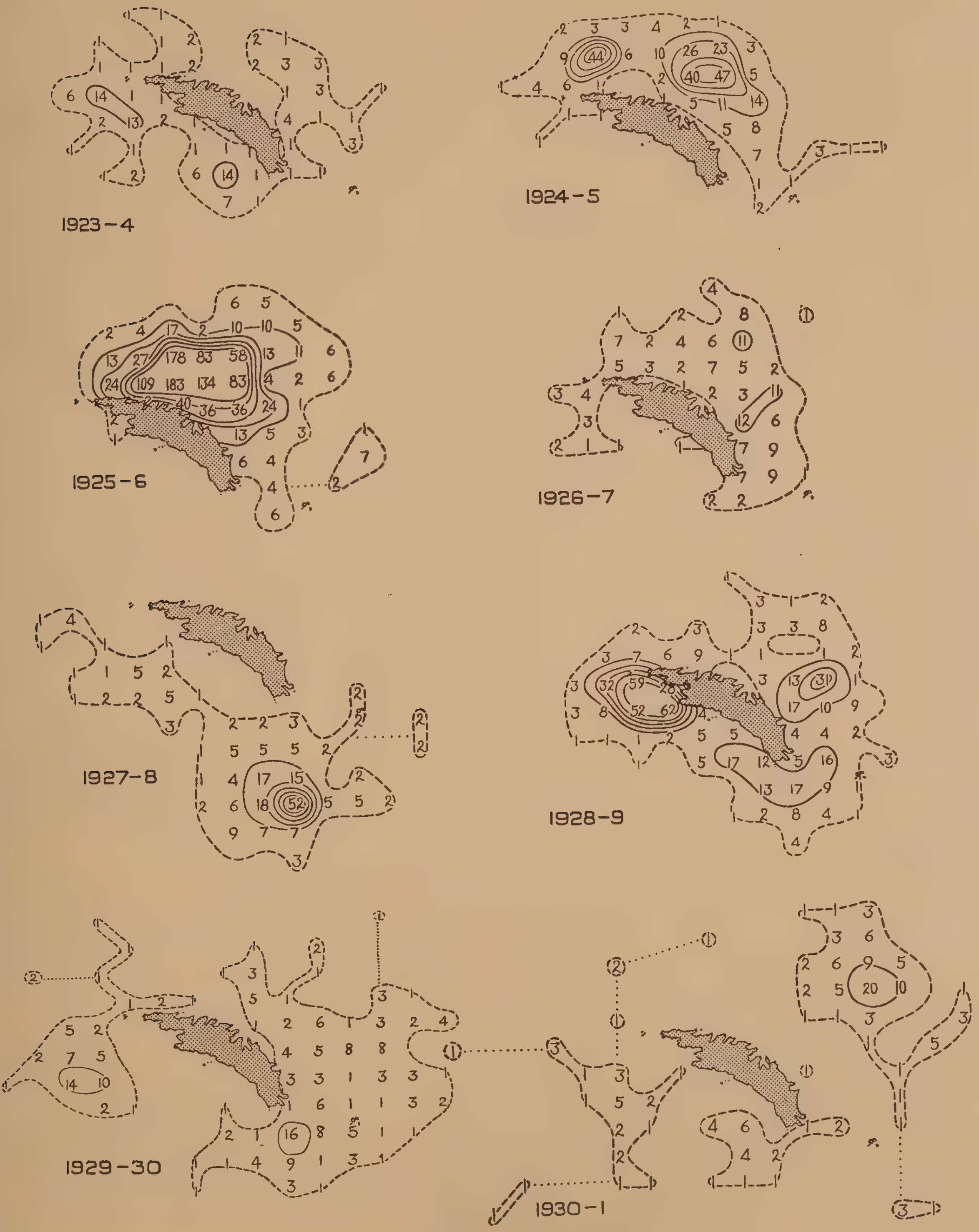
1923–4
1924–5
1925–6
1926–7
1927–8
1928–9
1929–30
1930–1

Fig. 142. The distribution of Fin whales in February of eight consecutive seasons (from Kemp and Bennett, 1932).

make the following very interesting remarks regarding the whale food of this South Georgia season of 1925–6, giving independent confirmation of our plankton results:

> Plenty of large krill were present in October and the first part of November, but they became scarcer later in November and in the first part of December. No whales were examined in the second half of December, but in January the large krill appear to have been suddenly replaced by a smaller type, scarce at first (unless the whales had difficulty in finding it) and then eaten in fair quantities. This krill seems to have become most plentiful in the earlier part of March. It is an interesting fact that the new type of krill which appeared in January was accompanied by a striking change in the whale population round South Georgia, for whales were very scarce during October, November and December, especially during December. But at about the new year immense numbers of Fin whales appeared. They were found first about 70 miles from the island and seemed to be finding very little food. Later they came closer to the coast and larger quantities of food were found in their stomachs.

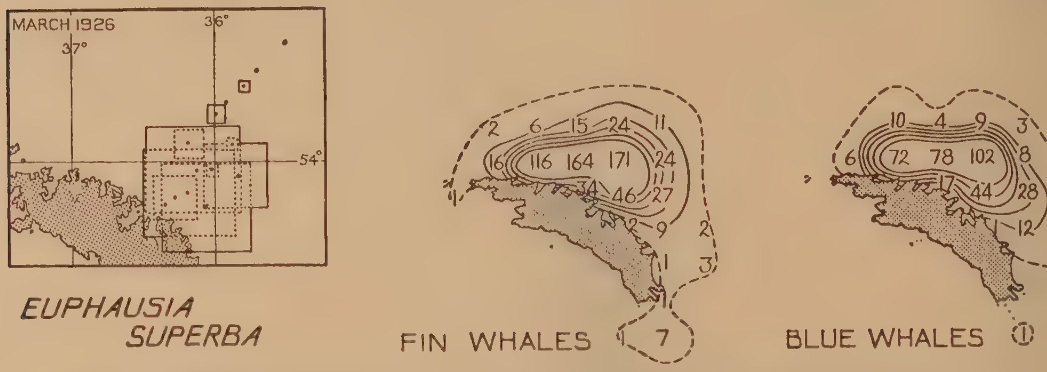

Fig. 143. *Euphausia superba* and whale distribution in March 1926 (whale distribution from Kemp and Bennett, 1932).

Few as these plankton observations are, combined with the observations of Mackintosh and Wheeler just quoted, they suggest strongly that the movements of the whales during their sojourn south are very intimately bound up with the distribution of their food. These conclusions are found to be strengthened by considerations to be discussed in the next section.

A FURTHER CONSIDERATION OF THE PLANKTON AND THE WHALE FISHERIES, WITH AN INTRODUCTION TO THE HYPOTHESIS OF ANIMAL EXCLUSION

It is now desirable to seek an explanation for the distribution of the *Euphausia superba*. At first temperature suggests itself. We know that they are cold-water forms, and we find them in the December–January survey situated off the north-east coast in water which is colder than that on the south-western side, where the Bellingshausen Sea current has the greater influence. Yet in March 1926, when they were concentrated in such large numbers against the coast, the temperature of the water they were in had an average for the top 50 m. of 2·6° C., which is greater than that found at any part, even off the western coast, during the December–January survey 1926–7. Further, in March the temperatures are *higher* at the stations against the coast than they are farther out in the region where few *E. superba* were met with. The average temperatures for the top 50 m. at five stations (13–17) passing out from the coast were:

2·86° C., 2·97° C., 2·51° C., 2·63° C. and 2·58° C.,

or the average for 150 m.:

2·70° C., 2·25° C., 1·92° C., 1·99° C. and 1·80° C.

Temperature cannot be a satisfactory explanation of their distribution, nor will salinity explain it. They are not spread throughout the water of Weddell Sea origin; in the tongue of this water to the south of the island they are present at only a few stations and only in small numbers. We have seen on p. 71 that we can distinguish two types of Weddell Sea water characterized by different plankton floras: phytoplankton groups 3 and 4. Whilst the water of "group 4" lies largely to the south it also extends up the east of the island, and here the Euphausians are as abundant in this water as they are in the water characterized by "group 3".

One of the striking features of the December–January survey was the dense production of phytoplankton in a belt along the south-west side of the island and round the southern end, as is shown in Fig. 38 on p. 74. This figure should be compared closely with Fig. 141 showing the distribution of *Euphausia superba* and whales. The main phytoplankton region to the south-west and south is unoccupied by Euphausians and whales; also it will be noted that the small dense concentration of phytoplankton centred at St. 124 off the north-east coast corresponds to a small number of Euphausians at that station as well as to a break between two main concentrations of Blue whales. Such a gap between these concentrations of whales would seem to indicate a shortage of their food at this particular point. It seemed possible that the distribution of the areas of dense phytoplankton might be linked in some way with that of *Euphausia superba* and possibly that of other plankton animals. *Salpa fusiformis* (Fig. 98) and *Parathemisto gaudichaudi* (Fig. 87) had a somewhat similar distribution to that of *Euphausia superba*.

Since the time of the Challenger Expedition a number of naturalists have noted an inverse correlation between phyto- and zooplankton. Castracane is quoted by the authors of the *Narrative of the Cruises of H.M.S. 'Challenger'* (Vol. 1, second part, p. 931, 1885) as having written regarding the expedition's plankton samples as follows: "Another observation, made during the examination of these surface gatherings, is that when the net yielded an abundance of different forms of microscopic animals, Diatoms were extremely rare; for this I have been unable to suggest any explanation other than that the Diatoms serve as food to the animals, so that where the latter are abundant the former are few in number."

Herdman (1888) reports that Mr I. C. Thompson found that "as a rule when the gelatinous algae are present very few of the ordinary surface animals such as Copepoda are found in the tow-net". Again, Herdman (in 1894) reports that Mr E. T. Browne found a "great decrease of Copepoda when the sea is full of Diatoms", and (in 1908) Herdman and Scott refer to a "general rule that Diatoms and Copepoda do not abound together".

It was shown by Pearcey (1885), who made a study of the dense phytoplankton concentrations in the region of the Shetland Islands in relation to the herring fisheries, that whenever his fishing vessel shot her nets in dense phytoplankton (*Rhizosolenia shrubsolei* and *Thalassiosira nordenskioldii*) the catch of herring was very small. He also noted that animal plankton was scarce in the regions of dense phytoplankton. In the same year Shrubsole (1885) records gelatinous organisms, from his description almost certainly *Phaeocystis*, reducing the catches of fish. Later Bullen (1908), for the Plymouth area, showed that zooplankton was usually scarce in regions of heavy phytoplankton, and that the heaviest catches of mackerel were taken in regions of least phytoplankton, although he appeared to attribute this to the relative scarcity of zooplankton in the phytoplankton regions rather than to the effect of the phytoplankton itself.

In 1921 I suggested that the poor herring fishery of that autumn might be due to a dense concentration of the diatom *Rhizosolenia* which I had observed on the fishing grounds,[1] and the following year I began experiments with the plankton indicator (Hardy, 1926) designed to obtain further evidence on the influence of phytoplankton on the herring. Only twelve records were obtained in the autumn of 1922, but they showed a zone of the colonial flagellate *Phaeocystis* stretching across the herring grounds. Six of the observations were made in regions of *Phaeocystis*, and here all six of the catches of herring were low, between 0·5 and 6 crans, and six observations were made in water free of *Phaeocystis* where the catches of herring were between 15 and 45 crans.[2]

Savage (1930), by some striking surveys of *Phaeocystis* patches at the time of the spring fisheries of 1924 and 1926, and the autumn fishery of 1927, gave valuable evidence in support of the influence of *Phaeocystis* on the herring, but in a recent paper (1932) expressed the view that there was little evidence that concentrations of diatoms had a similar effect. Mr Savage and I have now made (1935) a review of the possible influence of phytoplankton upon the fluctuations in the herring fisheries over a period of 12 years and we believe that there are good grounds for considering that the fluctuations of the autumn fishery are at least in part bound up with the phytoplankton, whether *Phaeocystis* or diatoms. Whilst Bullen seemed to imply that the mackerel were scarce in regions of phytoplankton because of the shortage in these areas of their food, the zooplankton, Pearcey considered that both fish and zooplankton were directly affected together. "In every case" he writes "where the nets were lying among *Rhizosolenia* not a single herring was caught, while outside of the diatomaceous zones they were found in abundance. Many experiments were made to test the exclusive power of the diatoms, all giving the same results." Farther on he says, "There can be no doubt, then, that this vegetable matter exercises a very great influence over the herring and the pelagic animals upon which they feed, as very little animal life was found amongst it". The fact that the herring in the East Anglian autumn fishery are not feeding (Hardy, 1924; Savage, 1931) shows that the effect on the fish can be a direct one. It should be mentioned that it has long been a tradition amongst herring fishermen that they will not catch herring in what they call "stinking" or "weedy" water, and such water has been shown to be due to dense phytoplankton.[1]

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[1] Hardy (1923).

[2] Experiments with the plankton indicator used on herring drifters have been continued recently by Hardy, Henderson and Lucas (report in preparation); out of 1256 plankton samples obtained with corresponding records of catches of herring it was found that in 55 phytoplankton predominated and coloured the disc green. The average catch of herring for these 55 occasions was 1·8 crans; the average catch for the remaining 1201 occasions when the discs were not coloured green by phytoplankton was 9·9 crans.

Fish (in 1925) published important observations on the correlation of zoo- and phytoplankton in the Woods Hole region of America. He writes as follows:

> Normal diatom maxima have no noticeable effect on the larger planktonic forms. When the unusually large swarms of phytoplankton appear, however, the zooplankton decreases rapidly and may even totally disappear for a time. Such conditions are often found during the summer maxima of *Rhizosolenia semispina*. Usually the winter maxima do not affect the larger forms. In the winter of 1922–3 the phytoplankton and zooplankton were both abundant at the same time. At this time *Rhizosolenia alata* was the dominant diatom. In 1923–4 *Nitzschia seriata* occurred in such abundance that the zooplankton disappeared almost entirely from November 16 until February 1. During this period top and bottom collections in the shallow water of the bay and sound yielded nothing but diatoms. The zooplankton was found to be fairly abundant in the deeper waters at the western end of the Sound. As soon as the diatoms declined in numbers the larger forms returned to the shallow water.

His curves showing the relative abundance of zoo- and phytoplankton are of great interest. The coincident abundance of the two in the winter of 1922–3 is for a short space of time at the end of December and beginning of January. This might possibly be of significance in that this is the time of minimum light intensity and so minimum photosynthesis.

In his general conclusions Fish writes:

> The pelagic diatoms exert a very great influence on the zooplankton. When the greatest maxima appear most of the zooplanktonic forms disappear. There are possibly two reasons for this. First, the common species having these swarming periods do not form the food of the zooplankton so far as I have been able to determine. During the maxima of the larger diatoms the smaller members of this group which are eaten by pelagic animals disappear, causing a scarcity in the food supply. This may account for the similarity in the time of disappearance of the larger forms and the small diatoms. Second, the great numbers of the diatoms filling the water apparently cause conditions unfavourable for animal life of any sort. The macroplankton seems to be literally choked out. This, however, is hardly probable, and is offered merely as a possible explanation.

In our survey it is the smaller forms of diatoms, such as the very minute *Chaetoceros socialis*, that have an inverse correlation with the zooplankton as much as the larger forms.

In this review of earlier work mention should also be made of the observations of Herdman (1907) upon the vertical distribution of the zoo- and phytoplankton, which is quoted in full on p. 324. He showed that when the diatoms were more abundant in the bottom waters the animals were at the surface and *vice versa*.

There are then two ways of considering this inverse correlationship between the planktonic plants and animals. The view first put forward by Castracane in 1885 that possibly the phytoplankton is abundant because of a shortage of animal plankton to keep it in check, and the second view first put forward by Pearcey in the same year, and suggested again by Fish in 1925, that dense phytoplankton excludes animal life from the water. This latter hypothesis I will refer to as that of animal exclusion.

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[1] See Addendum note on p. 364.

When the present section was in its early stages my colleague Mr C. E. Lucas, with whom I discussed the problem, emphasized the importance of the former view. For a number of reasons I rejected this hypothesis as a possible explanation of the apparent relationship between the distribution of the phytoplankton concentrations and that of *Euphausia superba*. A discussion of some of these reasons which strengthened my rejection of this hypothesis must be reserved until the data underlying them are described, but some of them may be mentioned here. Whilst it is clear that a shortage of herbivorous plankton animals must allow a greater multiplication of the phytoplankton if the conditions favourable to their growth, i.e. nutritive salts, light, etc., are present, it did not appear likely that such a shortage of herbivorous animals could account for the formation of the well-defined patches of dense phytoplankton that are found both in the Antarctic and the North Sea. Whilst on land herbivorous animals may keep slow-growing vegetation in check by grazing, in the sea it appeared likely that if conditions very favourable to the multiplication of the plants were present these unicellular organisms, which can double their bulk and separate at each division, could increase their numbers at a much greater rate than could be checked by the animals. The numbers of animals such as *Euphausia superba*, which takes two years to reach maturity and reproduce, could not increase to maintain the same balance of zoo- to phytoplankton that existed before the favourable conditions to plant multiplication set in. Whilst other smaller animals might multiply more quickly and help to restore the balance, it did not seem possible that *Euphausia superba* and the number of other plankton animals dealt with in the sections which follow could have this power. Again, it has long been recognized in temperate regions that the phytoplankton which is so abundant in spring becomes reduced by the feeding of the increasing zooplankton, and more recently it has been shown that this reduction is assisted by the retardation in the growth of the plants by the reduction of the available nutritive salts. Such a statement refers to the phytoplankton as a whole; actually within the general decline of total phytoplankton there may be a succession of different species which flourish and wane in their own season, some early and some late. To what extent the decline of the earlier ones is due to the multiplication of the zooplankton we do not know; we have however seen on p. 42 the sinking of vast numbers of dead *Coscinodiscus*.

From the findings of Savage and myself in the North Sea, an account of which has just been published, we believe that there is little doubt that the herring avoids dense concentrations of phytoplankton. Now the herrings at this time are not feeding (Hardy, 1924; Savage, 1931) but collecting preparatory to spawning. Thus they do not avoid the phytoplankton because of a lack of animal food therein, unless they do so because of a habit established in the summer feeding season. It appears unlikely that such a reaction should be maintained in the autumn, when it not only has no value in relation to feeding but would prevent them from reaching their normal shoaling grounds. The phytoplankton in the case of the herring appears to have the exclusion effect first suggested by Pearcey.

For these reasons I set myself to investigate the hypothesis of animal exclusion, particularly in relation to *Euphausia superba*, but also in relation to the animal plankton in general. Since this work has gone into first proof an important preliminary paper has been published by Harvey (1934) describing his investigations of the zoo- and phytoplankton relationships in the Plymouth area as the season advances. He favours the view that the phytoplankton is controlled by the numbers of herbivorous plankton animals present. Whilst for the reasons stated and those which follow I did not believe that the dense production of phytoplankton in the Antarctic or the North Sea can be due to a shortage of herbivorous animals in these areas, it is essential in the investigation of this important problem that we should keep our minds open to either possibility. As Mr Harvey has said in recent correspondence I have had with him, the conception of regulation of phytoplankton by grazing and animals avoiding very heavy phytoplankton are by no means antagonistic. In the light of Mr Harvey's investigations I have re-examined the data, and, as will be shown in the next section, have found some evidence that the phytoplankton may indeed be in part controlled by *Euphausia superba*, but that there is an indication that the remainder of the macroplankton organisms and some of the Copepoda may be excluded.

Another aspect of the problem must be borne in mind. Although I can recall no reference to the subject in the literature, in discussion planktologists have often commented on the possibility that the inverse correlation between phyto- and zooplankton may not be a real one but an apparent one, due to the tow-net becoming clogged by dense phytoplankton and so failing to capture more than a small proportion of the animals present on account of reduced filtration. This does not apply to the results about to be described.

Throughout all the stations of our South Georgia survey two nets of widely different mesh were used, one of 200 meshes to the inch for the capture of the phytoplankton, and one with a very coarse meshing partly 4 mm. mesh but with the end section of 15 meshes to the inch for the capture of the macroplankton including the Euphausians. This second net was of too wide a mesh to be clogged at all with the phytoplankton, so that here we have a parallel series of observations.[1] In Table LII are listed the numbers in which the five most abundant macroplankton species were taken by the N 100 H nets in the December–January survey of 1926–7 at all the stations where phytoplankton observations were taken; and the stations have been arranged, together with their corresponding zooplankton numbers, in order of the abundance of phytoplankton expressed as millions of cells per haul with the N 50 V net.[2] There are a number of difficulties that have already been noted in the section on zooplankton distribution that we have to contend

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[1] After the 1926–7 season the end of this net was changed to stramin on account of the fragile nature of the 15 meshes to the inch silk which frequently wore out. Stramin has a much lower filtration and is at times clogged by the dense phytoplankton.

[2] At only two stations, 139 and WS 26, was the N 50 V net not used. The zooplankton at these stations is not included in the table, but will be included in subsequent tables when the correlations of zooplankton and phosphate values are given.

Table LII

Average numbers of macroplankton (N 100 H nets) at stations in the South Georgia survey of December–January 1926–7, arranged in order of phytoplankton values

Phytoplankton in millions of cells	Station	*Euphausia superba*	*Euphausia frigida*	*Thysanoessa* spp.	*Parathemisto gaudichaudi*	*Salpa fusiformis*
0·003	WS 41	—	—	22	6	—
0·005	134	243	19	14	**142**	2
0·006	130	633	—	9	39	13
0·007	138†	**581**	—	35	**90**	208
0·009	WS 39	**762**	—	13	19	58
0·024	WS 42*	6	—	5	54	5
0·084	126	3	8	6	5	—
0·112	135	82	—	32	31	—
0·139	WS 29†	14	—	63	17	217
0·166	WS 38*†	172	16	56	**105**	**10,835**
0·187	127	—	2	3	16	—
0·241	128	—	—	**113**	16	16
0·276	136*	**3552**	**139**	53	**526**	458
0·323	133*†	**9653**	**154**	**101**	**1157**	**940**
0·341	WS 33	—	—	9	23	1
0·358	WS 27	2	—	—	—	—
0·378	WS 37	—	—	8	24	420
0·430	129*†	**6522**	**316**	**508**	**195**	**5,929**
0·458	WS 61*†	107	16	**115**	12	612
0·550	WS 28	2	—	1	7	—
0·582	WS 51	—	—	15	2	3
0·608	WS 36†	25	—	11	68	390
0·800	151†	141	—	**96**	39	252
0·936	WS 46*	6	—	**566**	24	54
1·116	132	**2109**	—	**94**	65	261
1·317	125*†	**2365**	**385**	51	**124**	**1,592**
1·800	137†	284	6	33	**148**	**1,385**
2·614	WS 63*†	372	**96**	74	**196**	**1,168**
3·328	131	**806**	1	36	16	2
4·643	WS 52	—	—	8	6	—
6·107	WS 50	—	—	18	1	—
8·259	WS 35*	—	—	30	**170**	182
11·06	124	4	—	**114**	46	5
18·26	WS 30*†	212	**107**	**768**	2	**1,514**
21·26	WS 34*	—	—	3	**108**	4
97·23	WS 31	4	—	23	38	17
99·05	WS 45	—	—	—	89	—
101·7	WS 43*	101	8	**227**	22	9
126·1	WS 47*	—	—	**116**	**122**	2
143·8	WS 44†	—	1	4	33	131
193·3	WS 40	179	—	32	28	202
502·6	WS 48	3	2	31	13	—
531·2	WS 49	3	2	25	9	—
	Average	673	30	84	90	625

Numbers in heavy type are those above the average.
* Night stations.
† Deep-water stations (see footnote 1 on opposite page).

Table LIII

Important species of macroplankton (N 100 H nets) at stations in the South Georgia survey of December–January 1926–7, arranged in order of phytoplankton values and averaged in six groups (one of eight stations and five of seven stations)

Phytoplankton in millions of cells	Number of stations averaged	*Euphausia superba*	*Euphausia frigida*	*Thysanoessa* spp.	*Parathemisto gaudichaudi*	*Salpa fusiformis*
3,000–112,000	8	289	3	17	48	38
139,000–341,000	7	**1913**	**44**	57	**266**	**1781**
358,000–608,000	7	**951**	**47**	**94**	44	**1051**
800,000–3,328,000	7	**869**	**76**	**136**	**87**	**675**
4,643,000–97,230,000	7	31	15	**138**	53	246
99,050,000–531,200,000	7	41	2	69	45	49

Numbers in heavy type are those above the average.

with in making correlations, particularly factors due to patchiness and to the vertical migration of these organisms into the region of the nets in larger numbers during the night than in the daytime. In Table LII the stations taken during the hours of darkness are marked with an asterisk,[1] and the numbers of the macroplankton organisms which are above the average are shown in heavy type. This table is summarized in Table LIII. In the summary table only one night station is included in the lowest phytoplankton range, but in the other ranges, taking them in ascending order, the night stations are 3, 2, 3, 3 and 2. Although the observations are few they suggest that these animals do not occur in large numbers where the phytoplankton concentrations are high. The indication that they do not also occur in large numbers in regions of poor phytoplankton, where perhaps there is insufficient food, is worth little in this series on account of there being only one night station in the lowest phytoplankton range, but later evidence discussed on pp. 301–309 gives some support to this conception.[2]

The question as to how the zooplankton organisms may come to be distributed in this way and the possible causes underlying their apparent exclusion from dense phytoplankton regions will be discussed later; we must first seek further evidence as to whether the correlation suggested here is a real one or not.

In March 1926 very few samples were unfortunately taken with the N 50 V net, but at the three stations where it was used, Sts. 23, 31 and 41 in the region of *Euphausia* concentration, very little phytoplankton was found, with the exception of moderate quantities of *Thalassiothrix antarctica* at St. 41 (33,000 cells for the N 50 V haul). At St. 12 (taken in February of the same year on approaching South Georgia from the north-east, and approximately 180 miles from the coast) a dense mass of the diatom

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[1] Since this section went into proof the deep-water stations, i.e. those in water over 500 m., have been indicated with a dagger and the possible significance of depth of water is considered on pp. 314 to 320.

[2] This is discussed further on pp. 350–351.

Thalassiothrix antarctica was encountered, and subsequently, by using the continuous Plankton Recorder towards South Georgia, we recorded a dense belt of this diatom for 80 miles or so. The instrument, owing to the presence of ice, was unfortunately not run right into the area examined in March, but was hauled up some 60 miles short of it.

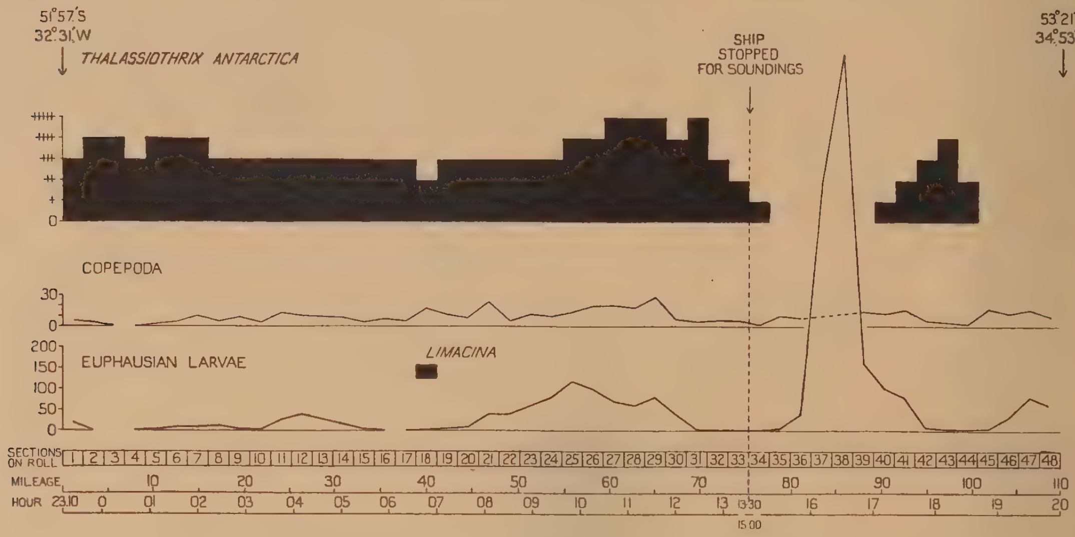

Fig. 144. Graphical representation of record obtained by the Continuous Plankton Recorder on approaching South Georgia from the north-east in February 1926.

Whilst the record, which is reproduced in Fig. 144, shows that the dense zone was coming to an end, the fact that *Thalassiothrix antarctica* was taken in moderate numbers at one of the stations in the March–April survey (St. 41) shows that in March it was still in the area and not far from the island. Whilst there is little relevant evidence here except that there was no dense phytoplankton in the region of the Euphausian concentration, the possibility, in the light of what follows, that in March the zone of *Thalassiothrix* may have extended farther in towards the concentration of Euphausians against the coast may perhaps be kept in mind. The inverse correlation between the dense patch of Euphausian larvae and the gap in the *Thalassiothrix* on the record in Fig. 144 is of interest.

We have seen in the 1926–7 South Georgia survey how closely the phosphate content of the water corresponded with the production of the phytoplankton. Their correspondence is shown in Figs. 38 and 39 and discussed in detail on pp. 79–84. In Fig. 145 the phytoplankton production in this survey is shown in a graph plotted against a scale of phosphate values, the phytoplankton values being averaged for the stations falling within each division of the phosphate scale. We have further seen how closely the whale distribution appears to be bound up with its food *Euphausia superba*. If there is an inverse correlationship between the distribution of the phytoplankton and *Euphausia superba* brought about either by the grazing or the exclusion of the latter, then, provided whales and Euphausians are present in the area, it should be possible from a knowledge of the distribution of the phosphate content of the area to deduce to some extent the distribution of the whales whenever the phosphate content is a fair measure of phytoplankton production. We should not expect to find whale concentrations in those parts of an area which had a markedly lower phosphate content than the rest. It is important to observe that the records of phosphate values give an indication of the production of phytoplankton over a *little time in the past*, a period of time, which would allow either the phytoplankton to be reduced by the Euphausians or allow the distribution of *Euphausia* to be adjusted according to the hypothesis of exclusion, and also that of the whales. We have demonstrated on p. 68 that measurement of phytoplankton either by the number of cells or by volume is not really satisfactory, so that an estimation by reduction in phosphate content for this and the reason just given may often be a better guide than actual phytoplankton measurements at the time. This will not invariably be so, because if phytoplankton production ceases and the crop dies down, then as time elapses phosphate measurements will lose their value as a guide.

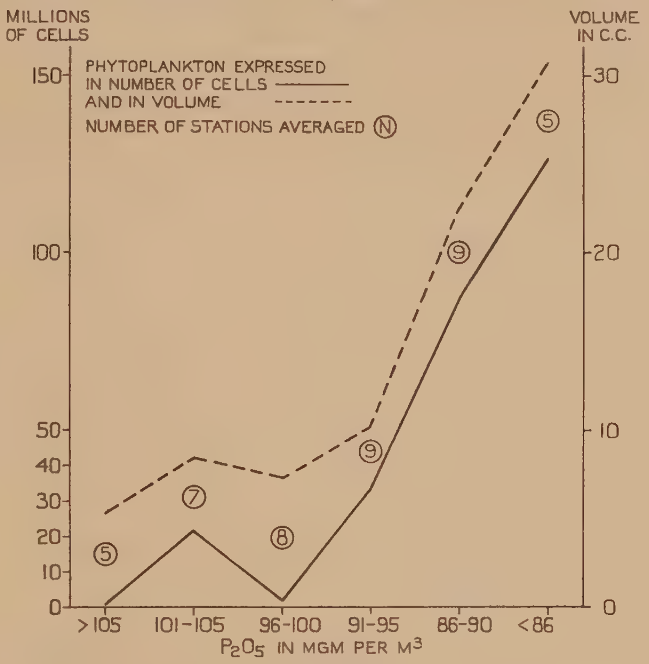

Fig. 145. Correlations of phytoplankton production with phosphate values averaged for the top 50 m.

Since the survey with which we are concerned was carried out the results of the phosphate determinations of later surveys have been published in the Station Lists in the *Discovery Reports*;[1] there are whale distribution figures published by Kemp and Bennett which correspond in time to three surveys at South Georgia and one at the South Shetlands. Supposing for a moment that the inverse correlationship between the phytoplankton and the Euphausians is correct, we will attempt to deduce the state of the whale fishery at each of these times from the corresponding phosphate distribution, and then compare the results of our deductions with the actual state of the fishery as reported by the industry. Fig. 146 shows the distribution of phosphate content off the northern, eastern and southern coasts of South Georgia in the December–January survey of 1928–9 expressed as an average for the top 50 m. It is seen that the greater part of the area has a relatively high phosphate content, the area shaded in the figure having a content of over 100 mg. per m.^{3}; to the south of the island, however, there is a region of somewhat lower content. From this we should expect that the greater part of the area was free of dense phytoplankton, but that there was more phytoplankton concentrated towards the south. That this phosphate

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[1] Station List 1927–9, *Discovery Reports*, Vol. III, pp. 1–134, and Station List 1929–31, *ibid.* Vol. IV, pp. 1–232.

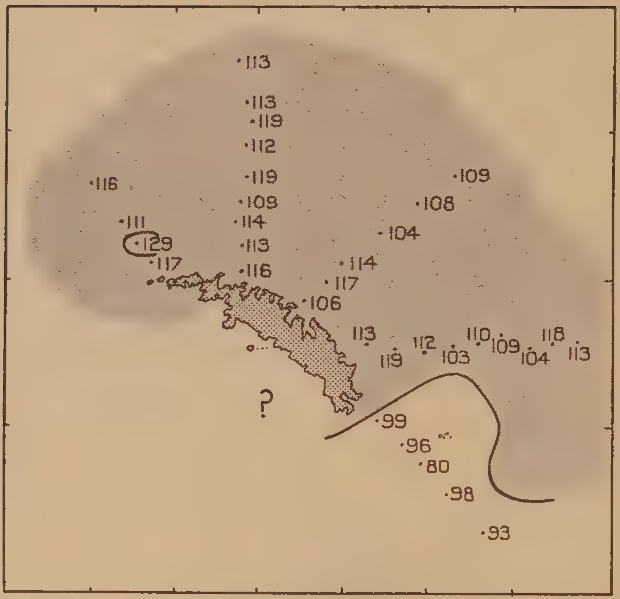
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Fig. 146. Distribution of phosphate values, averaged for the top 50 m., in the South Georgia survey, December–January 1928–9.

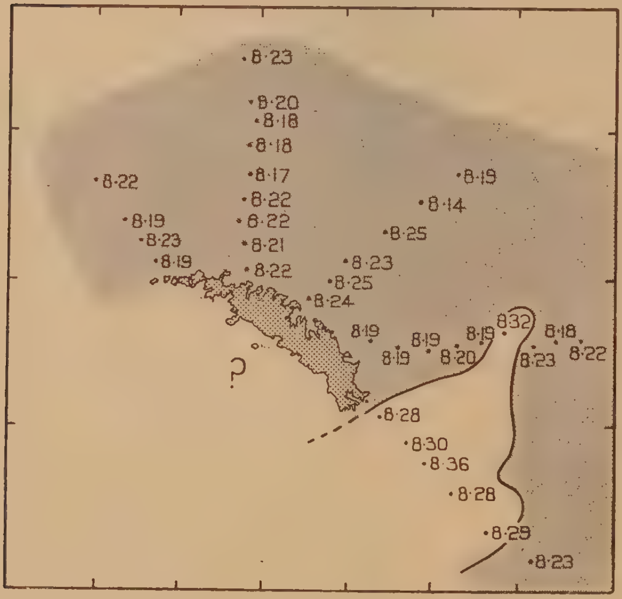
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Fig. 147. Distribution of *p*H values, averaged for the top 50 m., in the South Georgia survey, December–January 1928–9.

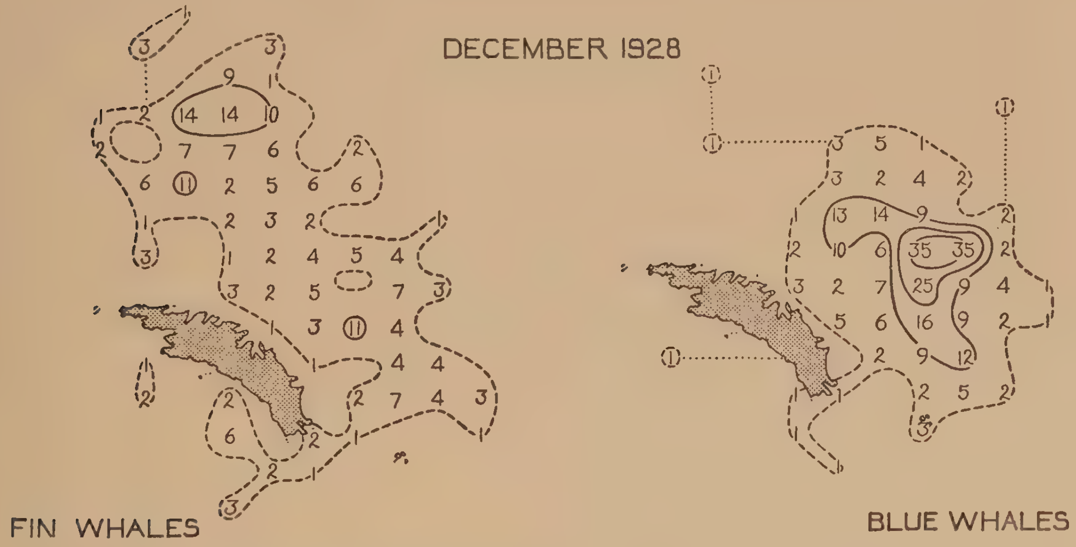

Fig. 148. Fin and Blue whale distribution, December 1928 (from Kemp and Bennett, 1932).

distribution does in fact bear a relation to the phytoplankton production over a little time in the past is shown by charting the average *p*H values for the top 50 m., when it is seen, in Fig. 147, that the higher *p*H values, those above 8·09, all occupy an area to the south closely similar to that occupied by the lower phosphate values, those below 100 mg. per m.^{3} A correlation graph of phosphate and *p*H values for this survey is shown in Fig. 150. Atkins (1923*b*) has shown how *p*H values can be used as a measure of phytoplankton production. We should now expect the Euphausians and so the

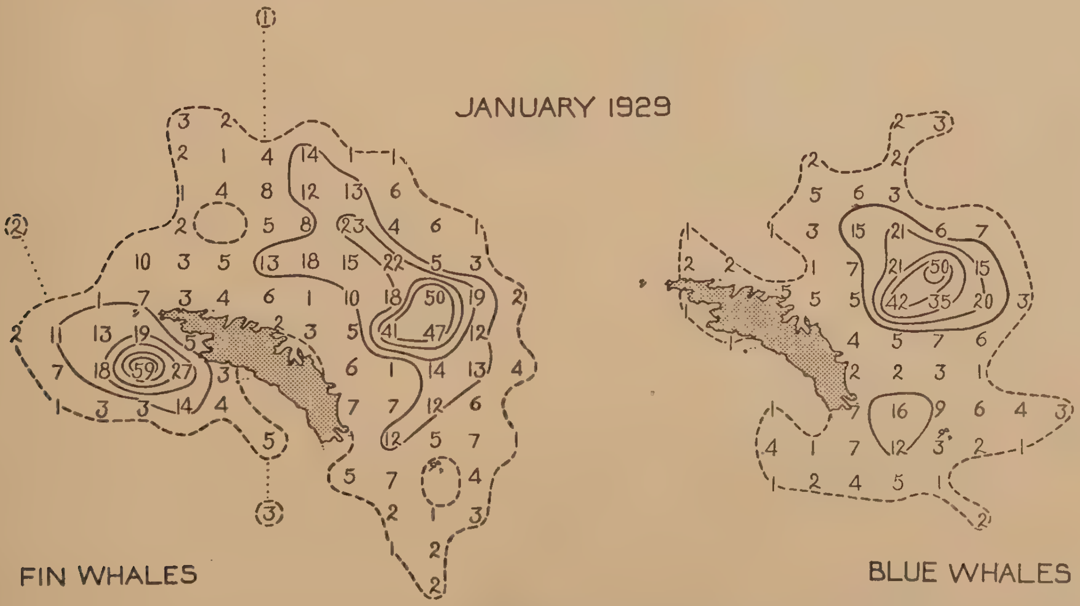

Fig. 149. Fin and Blue whale distribution, January 1929 (from Kemp and Bennett, 1932).

whales to be widely spread, but avoiding the region in the south. The distribution of Fin and Blue whales is shown for December in Fig. 148; the whales are widely spread but are not found off the south end of the island. In January (Fig. 149) whilst a few are taken to the south the majority are still taken in the area of higher phosphate content.

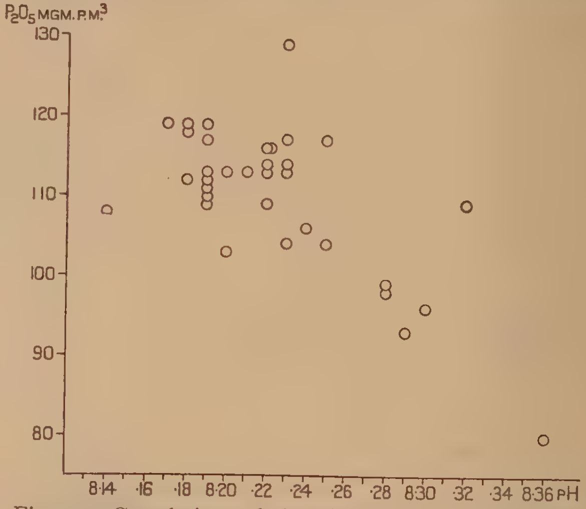

Fig. 150. Correlations of phosphate and *p*H values, each averaged for the top 50 m., at stations in the December–January 1928–9 survey.

Fig. 151 shows the phosphate content, again as an average for the top 50 m., round South Georgia in the survey of January–February 1930. Conditions here are quite different to those in December–January 1928–9. Most of the area is of low phosphate content, but there is a limited region of higher phosphate content off the north-east coast, a very small patch off the north end of the island, and another region of high phosphate content far to the west. These, having a phosphate content of over 90 mg. per m.^{3}, are shaded in the figure. Except for these regions, the area would appear to have been flooded with a dense crop of phytoplankton, and we should expect the Euphausians, and so the whales, to be concentrated in the areas of higher phosphate content. In Fig. 153 we see the actual distribution of the whales during January. The main concentration of Fin whales corresponds to that of the high phosphate content—there is even a small concentration off the north end of the island. The Blue whales, whilst in smaller numbers, have a distribution even more closely similar to that of the high phosphate values. In February the numbers of Fin whales taken (also shown in Fig. 153) were only just over a quarter of the number taken in January, and so few Blue whales were taken that no chart has been given by Kemp and Bennett. This would suggest that a supply of food originally concentrated in the small areas had either become exhausted or scattered by the end of January. In February a small concentration of Fin whales was found in the region of higher phosphate content far over to the west. The plankton and phosphate survey took place at the end of January and beginning of February—the dates are shown in the phosphate chart. Mr Hart, who has just published an account (1934) of the phytoplankton of this season, shows that *actually there was comparatively little phytoplankton at this time*. Nevertheless, the phosphate values, which are exceptionally low for this area when compared with other surveys, point to there having been a heavy crop of phytoplankton earlier in the season, and it appears likely that a former maximum efflorescence had died down by the time the survey was taken at the end of January and early February. The *p*H values give some support to this view. Fig. 154 shows a correlation between the *p*H values and the phosphate content in the survey, expressed as averages for the top 50 m., in which the

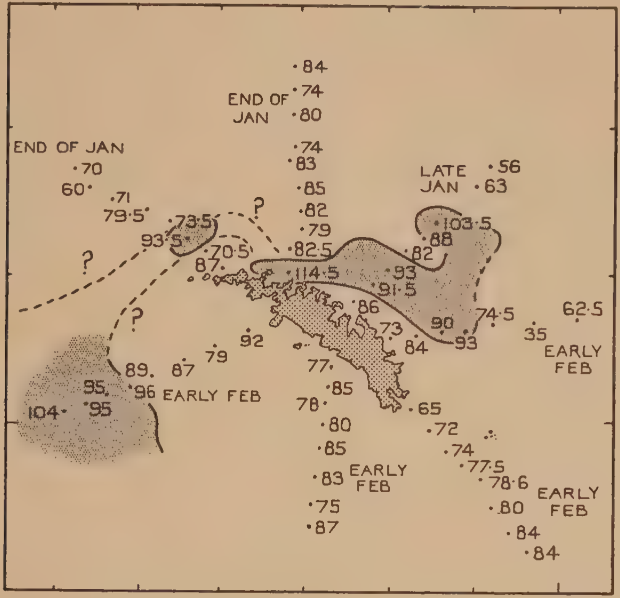
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Fig. 151. Distribution of phosphate values, averaged for the top 50 m., in the South Georgia survey, January–February 1930.

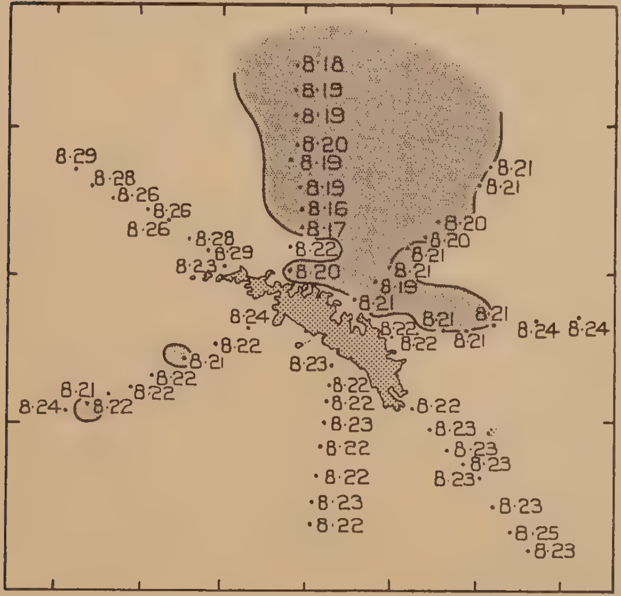
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Fig. 152. Distribution of *p*H values, averaged for the top 50 m., in the South Georgia survey, January–February 1930.

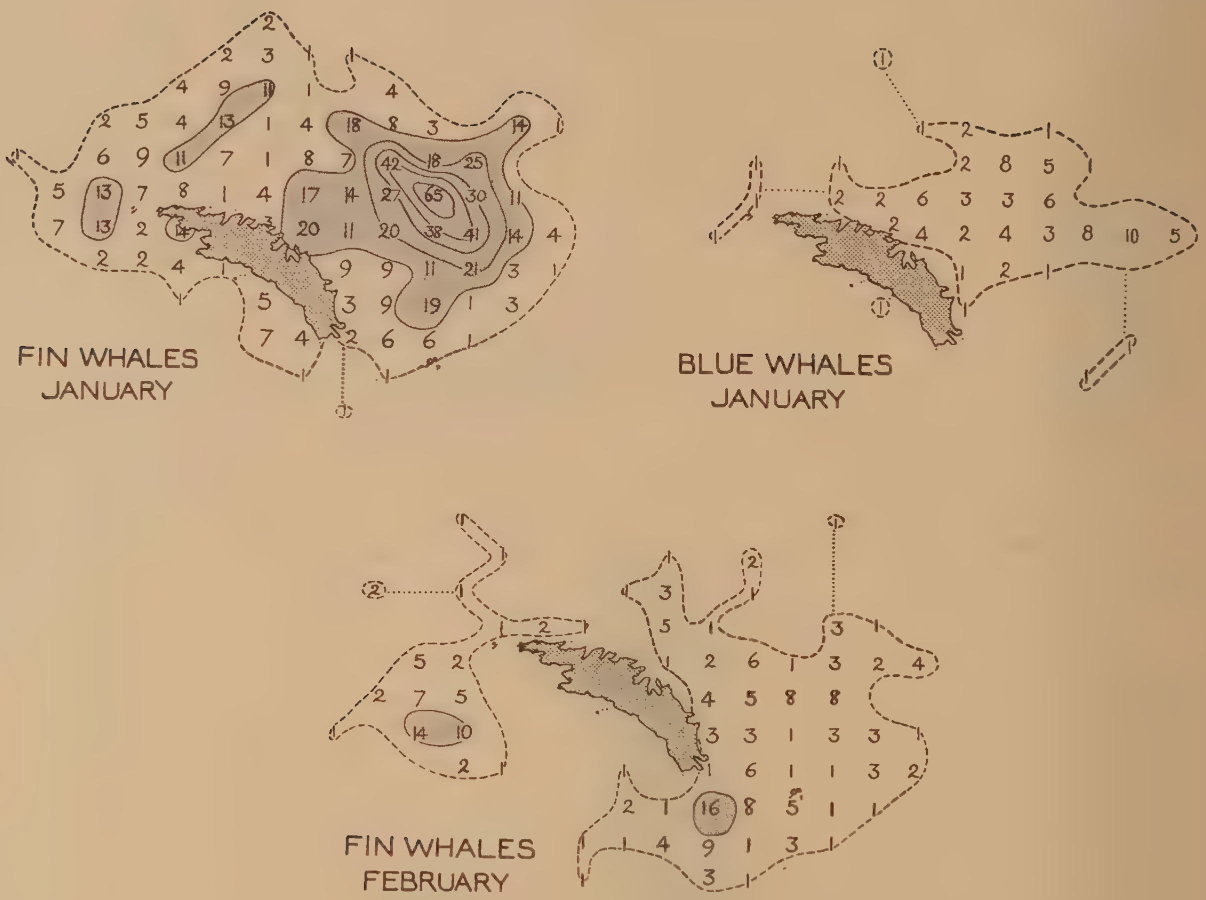


Fig. 153. Whale distribution in January and February 1930 (from Kemp and Bennett, 1932).

values at stations taken in January are shown as blacked-in circles and those in February as open circles. In January there is some, if only slight, correlation between the higher phosphate values and the lower *p*H values and between the lower phosphate values and the higher *p*H values. But in February high and low phosphate values all fall within a very limited range of medium *p*H values, indicating that whilst the reduced phosphate content remains to point to a former phytoplankton production the corresponding high *p*H values have not been maintained by a continuation of phytoplankton activity, and have been reduced by a restoration of the CO_2 balance by gaseous exchange with the atmosphere. Fig. 152 shows the distribution of the average *p*H values for the top 50 m.; the area of lower *p*H values covers roughly the same area as that of the higher phosphate values off the north-east coast, but in addition extends far to the north. It should be noted that the three northern lines, with the exception of the two outer stations on the north-east line, were taken in January. If the hypothesis of animal exclusion is correct we should expect the whale distribution to correspond to the areas of high phosphate content in January but not in February. This is what we find. The whales in February were reduced in numbers and were no longer concentrated off the north-east coast; this we should expect if the phytoplankton over the whole area had died down and no longer exerted an influence upon the Euphausians. The Euphausians, which we have supposed were originally concentrated in small areas, would now be free to scatter, so that the whales might find it more difficult to find sufficient food. The mechanism by which plankton animals become concentrated or dispersed will be discussed in a later section; hitherto they have been regarded as purely drifting organisms. A similar effect might be found if the opposite view is correct, i.e. if the smaller area of higher phosphate content was due to the Euphausians being concentrated at one place and keeping the phytoplankton in check, and the wider-spread lower phosphate values being due to a lack of Euphausians allowing the phytoplankton to flourish. The whales would be concentrated round the patch of Euphausians in January, but in February they might have so greatly reduced this stock of Euphausians as to be forced to scatter widely afield in search of food.

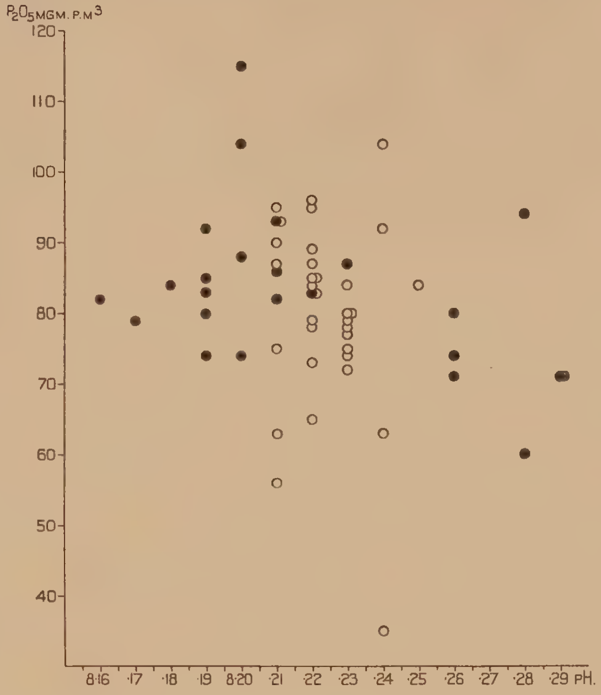
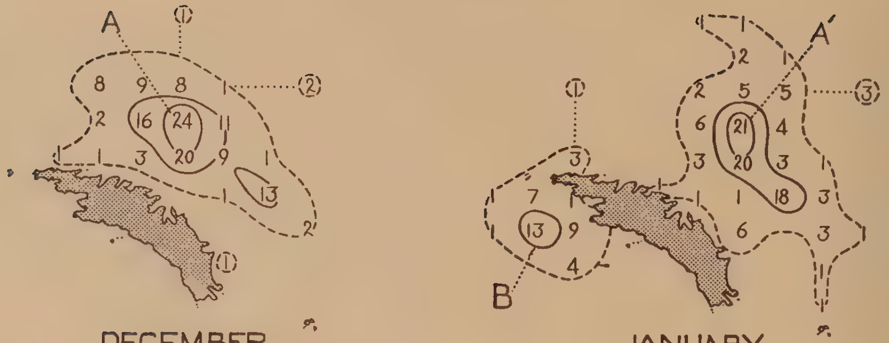


Fig. 154. Correlations of phosphate and *p*H values, each averaged for the top 50 m., at stations in the January–February 1930 survey. Those in January are shown as blacked-in circles, those in February as open circles.

Before we examine further examples of correlations between whale abundance and high phosphate values we must discuss an issue of considerable interest. If the patch of higher phosphate content, in the survey just described, represents an area in which a lower phytoplankton production had taken place, and so an area of concentration of Euphausians which accounted for the concentration of whales in January, how is it that this patch of higher phosphate content remained in the same place to be recorded in the survey at the end of January and the beginning of February? If the phosphate figures represent what has happened over a considerable interval in the past, it might be expected that this patch would by the action of currents have a position earlier in January a long way away from that which it occupied at the time of the survey, i.e. a long way away from that occupied by the whales. In the open ocean such a patch must change position rapidly, but against an island such as South Georgia swirls would appear to be set up which must maintain their position for a considerable time. Fig. 155 shows concentrations of Fin whales in December–February 1923–4. It is inconceivable that the whales should remain concentrated at one spot in the feeding season without there being concentrations of food there. It is difficult to believe that the concentrations *A*



DECEMBER

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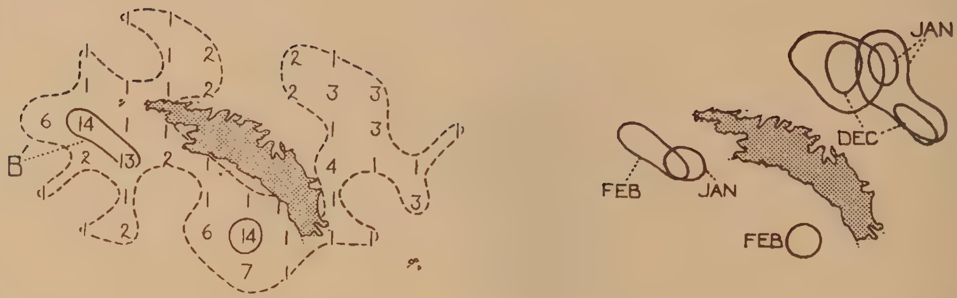
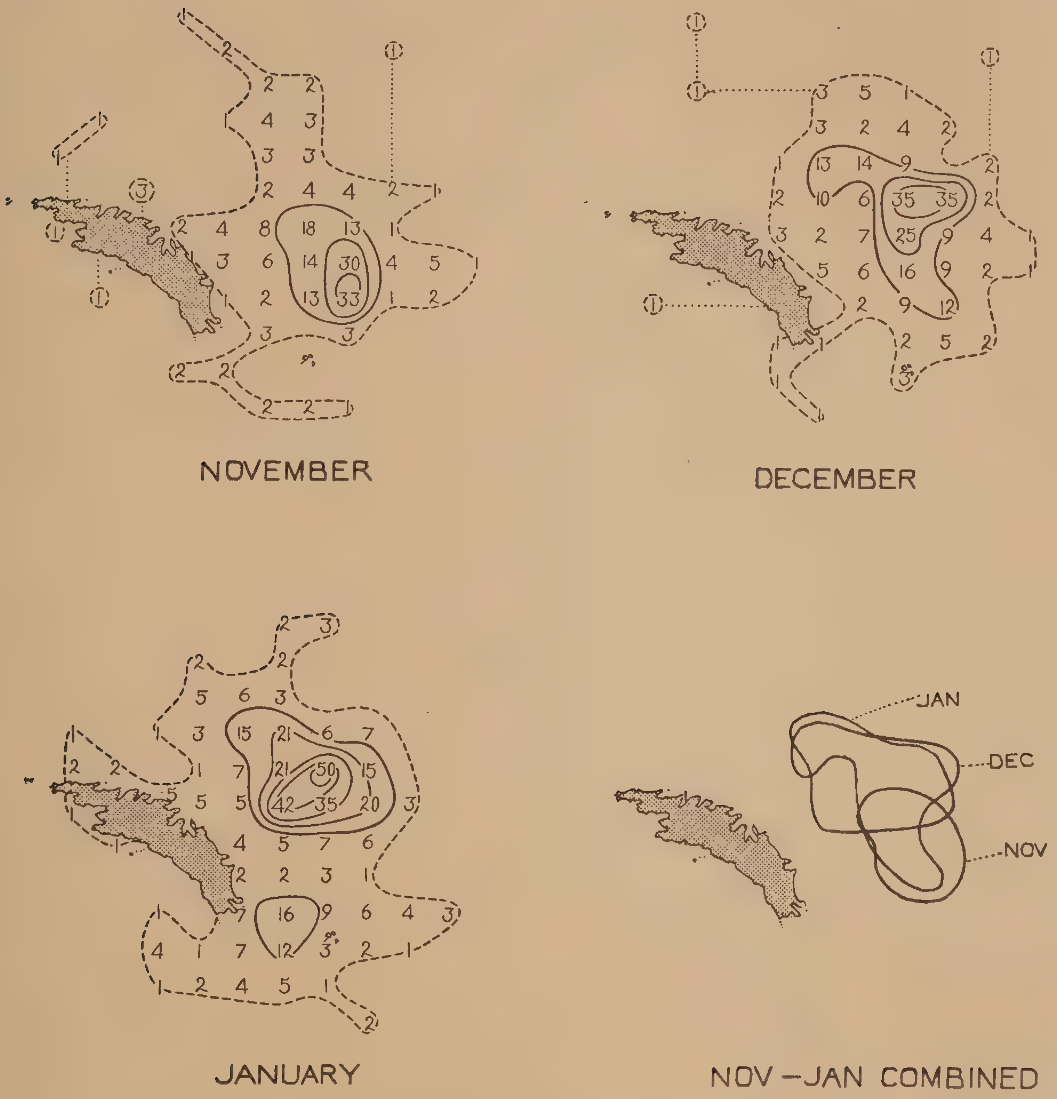


FEBRUARY

DEC—FEB COMBINED

Fig. 155. Concentrations of Fin whales from December to January 1923–4 (from Kemp and Bennett, 1932).

and *A′* and *B* and *B′* are not due to the same patches of food. There are many such instances in Kemp and Bennett's report of concentrations being maintained over two months. Some of these may represent concentrations which took place just at the end of one month and the beginning of the next, but Fig. 156 shows such a concentration extending from November to January. That the whales were definitely concentrated at these points is shown by the fact that whalers took a few whales over a wide area outside —they were evidently looking for whales in different directions but could only find them in numbers at the small area of concentration. This must mean that patches of food, particularly in the lee of the island, can remain for a long time in the same place. The whales would not be concentrated at one spot for a long time if their food was not there, and if the patch of food was moving, as no doubt it would be in the open ocean, then the concentration of whales would move and we should get a more spread-out whale distribution. Swirls of this nature have been demonstrated by Tait (1930) in the North Sea from his drift-bottle experiments. It seems likely that Kemp and Bennett's report on the whale distribution from month to month provides a valuable insight into the hydrographic conditions round South Georgia.



NOVEMBER

DECEMBER

JANUARY

NOV—JAN COMBINED

Fig. 156. Concentrations of Blue whales from November to January 1928–9 (from Kemp and Bennett, 1932).

Fig. 157 shows the phosphate values for the South Georgia November survey of 1930. Mr Hart, in the report already referred to (1934), has published the phytoplankton results of this survey also. The disagreement of the distribution of the phytoplankton at the time of the survey with the phosphate values is not so marked as in the January–February survey just discussed, but the agreement is by no means a close one. However, the correlation between phosphate and *p*H values, shown in Fig. 160, is very marked, and again leads one to regard the phosphate values as a good guide to the phytoplankton production *over a little time in the past*. A chart of the *p*H distribution is shown in Fig. 158, where the area of low *p*H values to the north-east of the island is seen to correspond with the area of high phosphate values. Fig. 159 shows the distribution of Fin and

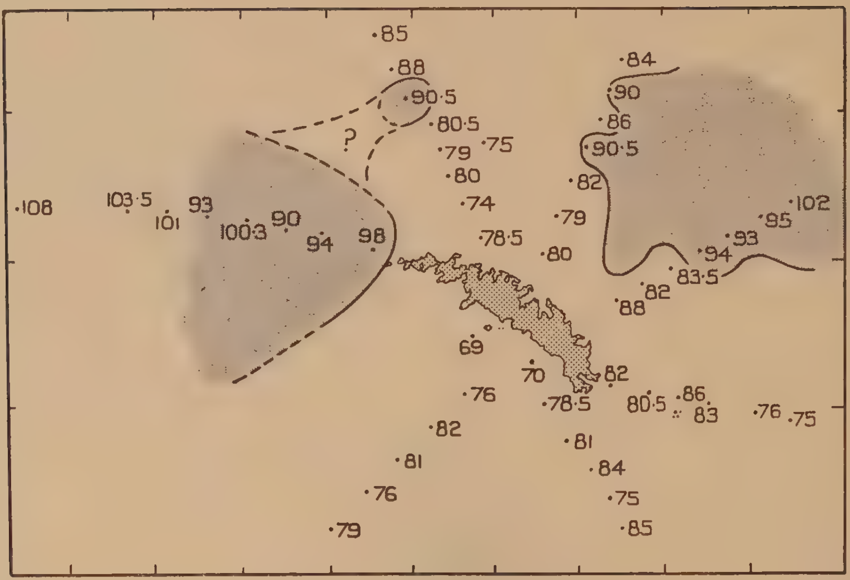


Fig. 157. Distribution of phosphate values, averaged for the top 50 m., in the South Georgia survey, November 1930.

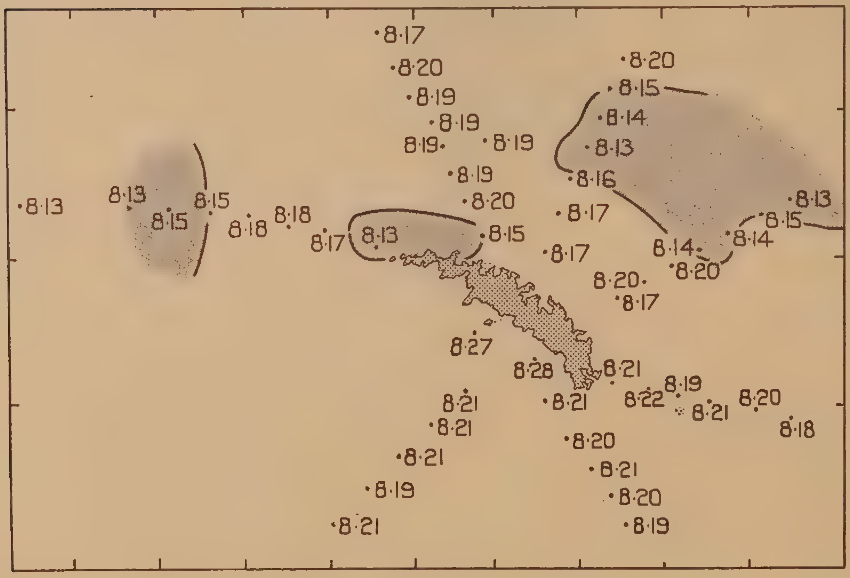


Fig. 158. Distribution of *p*H values, averaged for the top 50 m., in the South Georgia survey, November 1930.

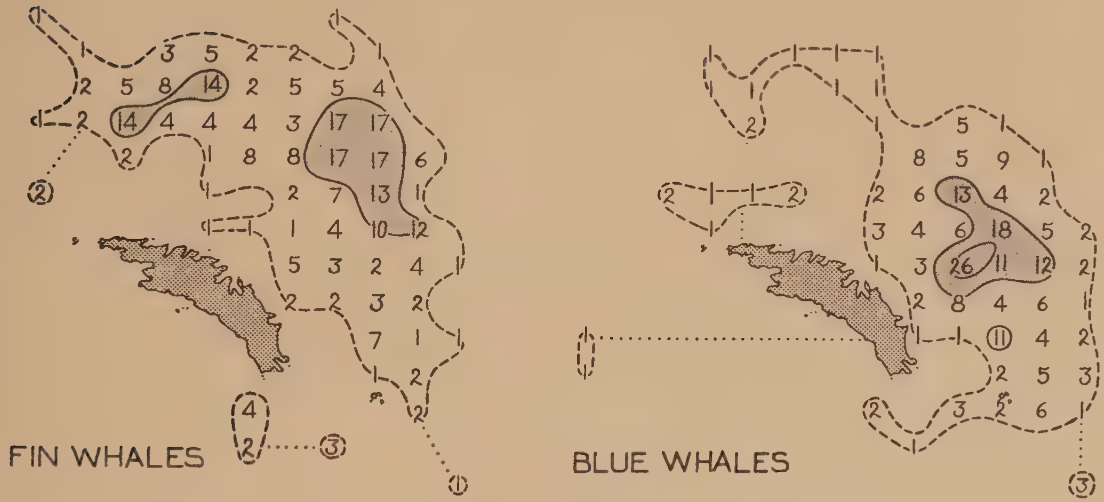


Fig. 159. Whale distribution in November 1930 (from Kemp and Bennett, 1932).

Blue whales at the same time. We see that the majority of whales of both species were taken in the region of high phosphate content and low *p*H values to the north-east, whilst we also see an interesting lesser concentration of Fin whales coinciding with the small patch of higher phosphate content to the north. No whales however were taken, as might have been expected, in the region of higher phosphate and lower *p*H values to the north-west. The major importance of these correlations is that whales are not found in any numbers in regions of *low* phosphate content.

Turning now to the South Shetlands survey of February 1929, the only one for which phosphate values together with whaling figures are as yet available, the phosphate content is plotted in Fig. 161. The phosphate values in these latitudes farther south are much greater even than those at South Georgia, but here also are areas of higher and lower phosphate value. We see an area of very high phosphate content close against the Weddell Sea, where presumably very little phytoplankton production has taken place, and an area of comparatively low phosphate content where presumably there has been a heavy production. The *p*H values are plotted in Fig. 162 where the area of higher *p*H values, i.e. those of 7·95 and over, is seen to correspond roughly with the area

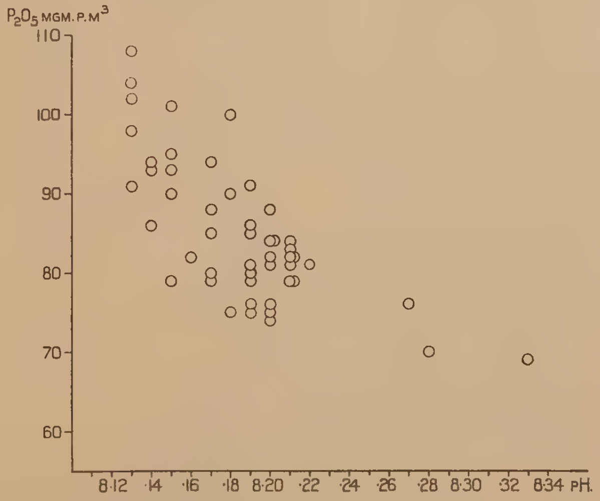


Fig. 160. Correlations of phosphate and *p*H values, each averaged for the top 50 m., at stations in the November 1930 survey.

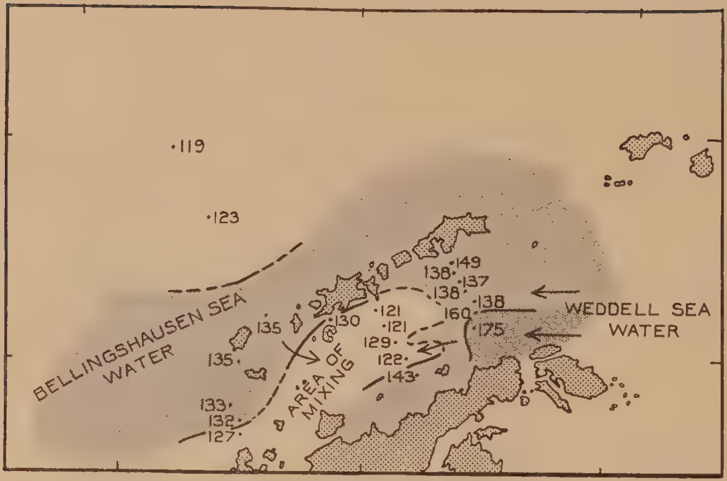

·119
·123
BELLINGSHAUSEN SEA WATER
AREA OF MIXING
WEDDELL SEA WATER
138·
·149
·137
·138
·138
160·
·175
·121
·121
129·
122·
143·
·130
135
135·
133·
132·
127·

Fig. 161. Distribution of phosphate values, averaged for the top 50 m., in the South Shetlands survey, February 1929.

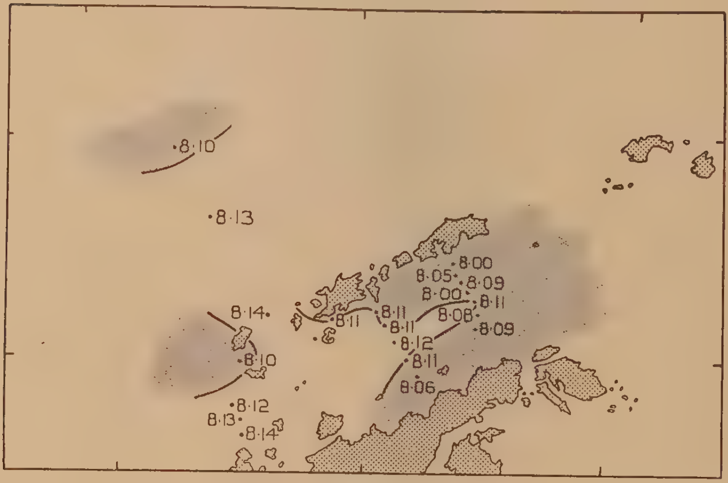
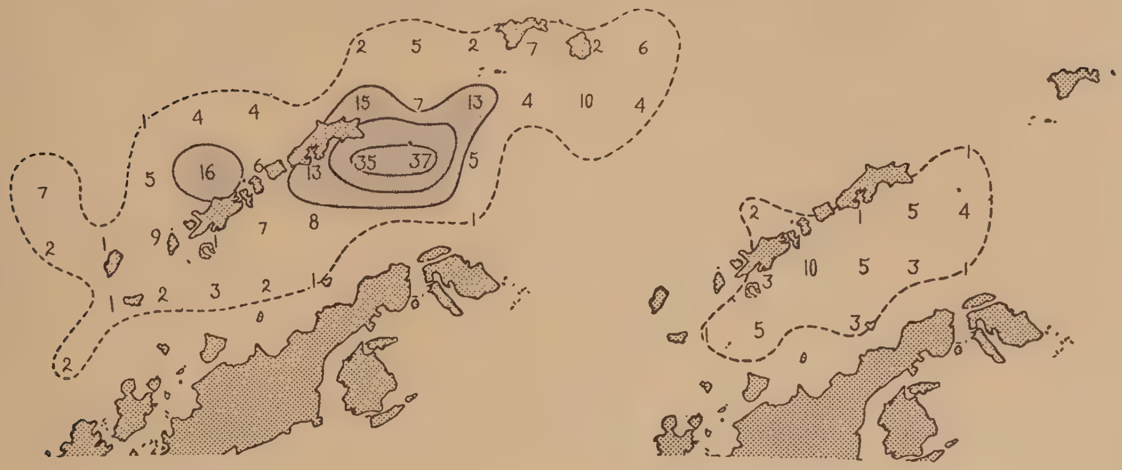

·8·10
·8·13
8·14·
·8·10
·8·12
8·13·
·8·14
·8·11
·8·11
·8·11
·8·00
8·05·
·8·09
8·00·
·8·11
8·08·
·8·09
·8·12
·8·11
8·06

Fig. 162. Distribution of *p*H values, averaged for the top 50 m., in the South Shetlands survey, February 1929.

of lowest phosphate value. We might expect the Euphausians to be in the area of phytoplankton concentration most suited to them, i.e. where food is sufficient but not too much to exclude them, thus not in the region of very high or very low phosphate content; or from the opposite point of view we should also expect few Euphausians in the area of lower phosphate content. Fig. 163 shows the distribution of Fin and Blue whales. There were very few Blue whales, but the larger number of Fin whales were found in the area of intermediate phosphate content. Kemp and Bennett (1932, pl. xl) show the average distribution of Fin and Blue whales on the South Shetland grounds based on all recorded positions of capture during the eight seasons 1922–3 to 1929–30. Usually the greater number of whales are taken in a position to the south-west of the concentration shown in Fig. 163.



FIN WHALES

BLUE WHALES

Fig. 163. Whale distribution at South Shetlands in February 1929 (from Kemp and Bennett, 1932).

To test the hypothesis of animal exclusion or the opposite interpretation further a deduction was made in the other direction. In February–March 1928 the 'William Scoresby' took a number of phytoplankton samples off the north-east and south-east coasts of South Georgia, but no phosphate observations. The whales had the distribution shown in Fig. 164, a distribution which is almost the opposite of that seen in our 1926–7 survey (Fig. 141). From this, if the animal exclusion or the opposite hypothesis is correct, one would deduce that the phytoplankton conditions were the reverse of those in 1926–7 (Fig. 38), and that there would be a zone of dense phytoplankton stretching along the north-east side of the island. It is unfortunate that phytoplankton samples were not taken on the western side of the island. Only some of the samples had been analysed, but Dr Kemp kindly had all their volumes measured and sent me the results, which are plotted in Fig. 165, using the same contour scale as was used in the volume chart of the 1926–7 survey. A dense belt of phytoplankton is seen round the eastern side of the island a little way from the coast. Dr Mackintosh has kindly provided me with figures of the *Euphausia superba* distribution for this survey; these I have plotted in Fig. 166 putting in in addition the outlines of the phytoplankton contours from Fig. 165. We see again that the Euphausians are not in the region of dense phytoplankton, but are found in the belt of medium phytoplankton separating the dense from the poor phytoplankton. The February whaling concentration was quite to the west of the southern line of stations, so that the Euphausians in this position were not sampled, but its position lies in the probable path of the continuation of the medium phytoplankton zone, so that a concentration of Euphausians might be expected there. Actually the southern line was taken in early March (the dates of the lines of stations are given in the charts), and from Fig. 167 we see that in March the whale concentration had broken up and comparatively few whales were taken. Some of the Fin whales in March still extended to the west of the island, but it is also seen that a small number were moving up the east coast along the belt of Euphausians inside the dense phytoplankton zone.

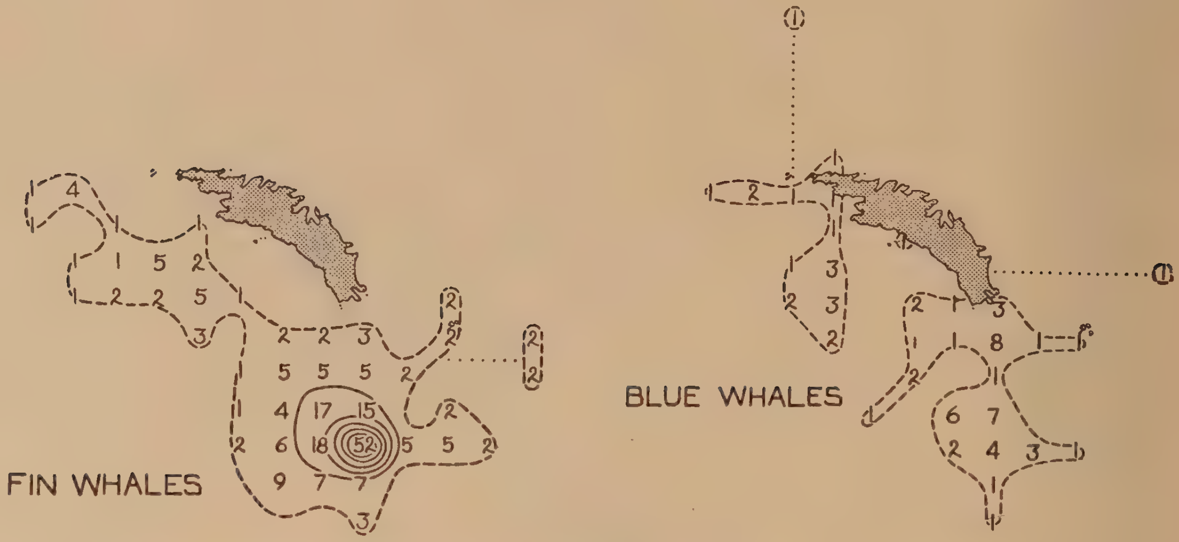

FIN WHALES
4
1 5 2
1
2 2 5
1
3
2 2 3
2
2
2
2
5 5 5 2
1 4 17 15
2
2 6 18 52 5 5 2
9 7 7
3
BLUE WHALES
1
2
1
3
2 3
2
2 1 3
1 8
2
1
6 7
2 4 3
1

Fig. 164. Whale distribution at South Georgia, February 1928 (from Kemp and Bennett, 1932).

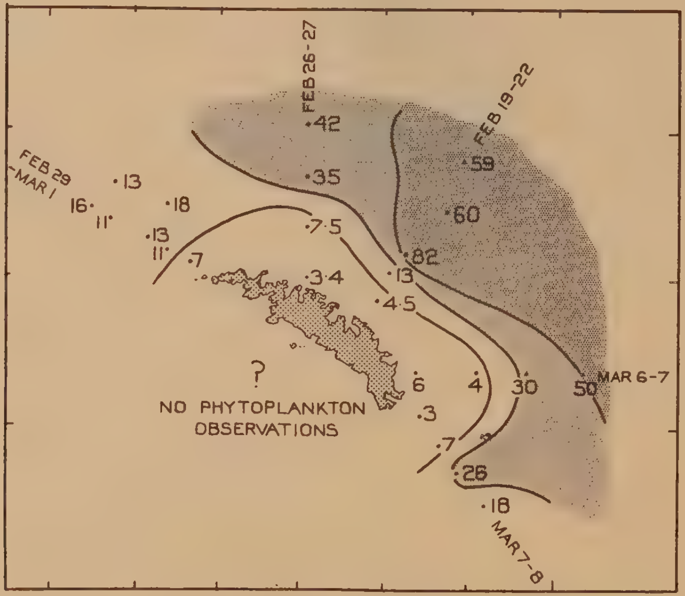

FEB 26-27
FEB 19-22
FEB 29 -MAR 1
·42
·35
·59
·60
·82
·13
16·
11·
·18
·13
11·
·7
·7·5
·3·4
·13
·4·5
?
NO PHYTOPLANKTON OBSERVATIONS
6
4
30
50
MAR 6-7
·3
·7
26
·18
MAR 7-8

Fig. 165. Distribution of phytoplankton measured in volume, cc. per 100 m. vertical haul with N 50 V net, at South Georgia, February–March 1928.

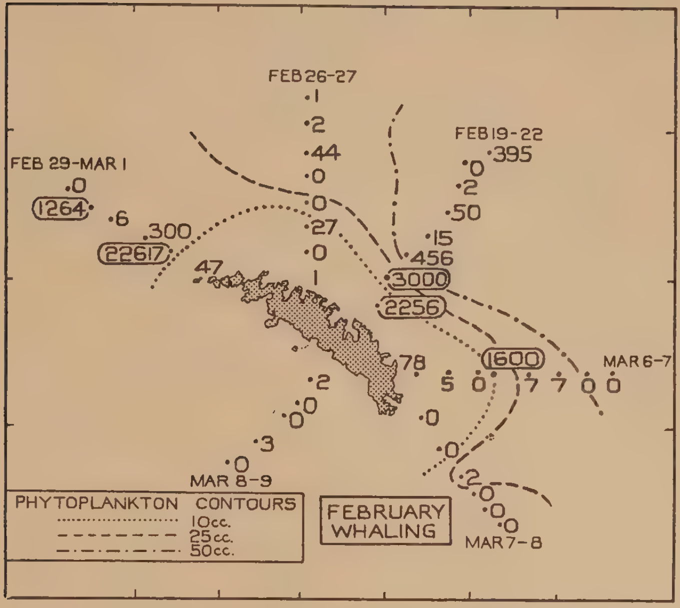

FEB 26-27
1
2
44
0
0
27
0
1
FEB 19-22
0
395
2
50
15
456
3000
2256
FEB 29-MAR 1
0
1264
6
300
22617
47
78
1600
MAR 6-7
5
0
7
7
0
0
2
0
0
0
3
0
MAR 8-9
0
2
0
0
0
MAR 7-8
PHYTOPLANKTON CONTOURS
10cc.
25cc.
50cc.
FEBRUARY WHALING

Fig. 166. Distribution of *Euphausia superba* in the February–March survey of 1928 shown as numbers per oblique haul with N 100 B net. The phytoplankton contours from Fig. 165 are superimposed and the position of the February whale concentrations shown.

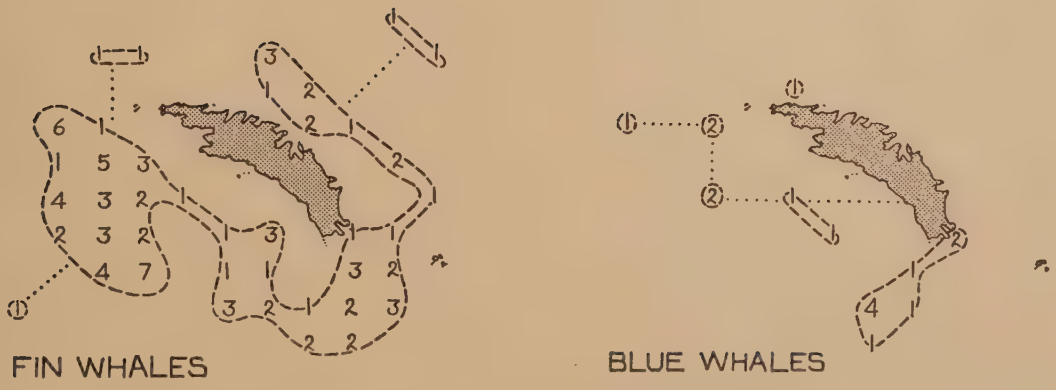

FIN WHALES
BLUE WHALES

Fig. 167. Whale distribution at South Georgia, March 1928 (from Kemp and Bennett, 1932)

The probability that these correlations in six instances (including December–January 1926–7) between the distribution of the whales and that of the phosphate values are due to chance must be small. That the distribution of two species of whale are so closely similar shows that they are being influenced by the same factor. We know that the two species feed exclusively upon the same species of *Euphausia*, and we have seen how closely their distribution in March 1926 and December–January 1926–7 appeared to be bound up with the distribution of this Euphausian. We have seen how very closely the pattern of phosphate consumption agrees with the pattern of phytoplankton production in the December–January survey, also in the results of Kreps and Verjbinskaya (1930) and from Gran's (1931) treatment of Ruud's samples from the Weddell Sea, referred to on p. 78. In addition we have seen how the phosphate values of other surveys are inversely correlated with the *p*H values. We have seen how the Euphausians are distributed in December–January 1926–7, away from the densest production of phytoplankton, as they are also in the figures of Mackintosh in the survey of 1928 given above.

The evidence would appear to point to the conclusion that the distribution of the phytoplankton is inversely linked with that of the Euphausian *E. superba*, and that the distribution of this Euphausian closely governs that of the whales. The possibility that the phosphate content of the water acts directly upon the Euphausians or the whales, or both, will be discussed and dismissed in a later section (p. 332). It is, of course, possible but hardly probable that the phytoplankton might act directly upon the whales themselves as well as on the Euphausians, and most probable that the whales will as a matter of behaviour avoid the dense phytoplankton knowing that the Euphausians are not to be found there. Plate xxiii in the report by Kemp and Bennett shows the distribution of all the Blue and Fin whales taken around South Georgia in the seasons 1923–4 to 1930–1, and we see that the distribution of the whales at the time of our survey in December–January 1926–7 conformed to the general pattern of the fishery taken as a whole over all these years. This is fortunate, for one may conclude that the planktonic conditions during our detailed survey were fairly normal for the area.

A FULLER EXAMINATION OF THE HYPOTHESIS OF ANIMAL EXCLUSION

We have seen that in general the greater the phytoplankton production the greater is the reduction in the phosphate content in the water, and we have seen that relative reduction in phosphate content would appear to be a better index in studying the interrelationship between phyto- and zooplankton than phytoplankton itself, not only because measurements of phytoplankton either by numbers of cells or by volume are so unsatisfactory, but because the relative reduction in phosphates at different stations gives a measure of phytoplankton production *over some little time in the past*. The phytoplankton crop will not always bear a relation to the contemporary phosphate values; in our survey, at the inshore stations WS 41 and WS 42, there is evidence that the water previously bore a rich phytoplankton which at the time of observation had died down (see p. 84). We will now attempt to correlate all the zooplankton organisms which occur in sufficient numbers with the distribution of phosphate values.

All the stations in the South Georgia survey of December–January 1926–7 have been arranged in descending order of phosphate values, ranging from 113 mg. per m.^{3} at St. WS 26 to 74 mg. per m.^{3} at St. WS 49. We will deal first with the macroplankton taken in the N 100 H nets. Three of these nets, it will be remembered, were towed horizontally and simultaneously at each station for one mile, one net being towed just below the surface at about 5 m. depth, another at a depth of about 50–75 m., and the third at a depth of about 100–150 m. The two lower nets were closed at the end of their mile tow before being hauled to the surface. In the present calculations the total number of each organism taken in all three nets has been used. The stations have now been grouped in six ranges of phosphate values: those above 105, 100·5–105, 95·5–100, 90·5–95, 85·5–90 and those below 85. (Actually the five stations below value 85 all have values not exceeding 80, viz. 80, 80, 79, 78 and 74.) In Table LIV the average number of each organism for the stations in each phosphate range is given. The highest or higher of these average numbers for each organism are shown in heavy type. We see that if one exceptionally high catch of *Euphausia superba* and one of *Eukrohnia hamata* are omitted, the majority (*Calanus acutus*, *Rhincalanus gigas* and *Antarctomysis maxima*, being referred to presently as interesting special cases) show an optimum concentration about the phosphate values 90·5–100. That is, smaller numbers are in the regions of high phosphate content (and therefore low phytoplankton production) and also smaller numbers in regions of low phosphate content (and therefore high phytoplankton production). We have seen that a difficulty is to be contended with in making such correlations, in that some organisms make such a marked diurnal vertical migration that more may be taken in the nets during night stations than during the daytime. This does not apply to all organisms, since some hardly sink below the level of the lower net in the daytime, but it undoubtedly applies to others. This being so, these apparent correlations may be fallacious, since the proportion of night stations to day stations happens to be higher in the groups of stations ranging in phosphate value from 90·5 to 100 mg. per m.^{3} than in those where the range is above and below these values. The number of night stations in each range of phosphate values is given in the table.

To see if these correlations are in this way fallacious or not we may divide the stations into two series, those taken in daylight and those taken in hours of darkness. Sunset and sunrise are taken as divisions between light and darkness. Because of that other difficulty we have to contend with in making correlations—namely patchiness of the plankton and the smaller number of stations that we can now average—we have taken for comparison wider ranges of phosphate value and divided the stations into three groups of as nearly equal numbers as possible. In the daylight series we have taken ranges of phosphate values over 100 mg. per m.^{3}, 90–100 mg. and less than 90 mg., giving groups of 10, 10 and 9 stations respectively; in the night stations we have taken phosphate values of over 97, 92–97, and below 92, giving groups of 6, 5 and 5 stations.

Table LIV

Correlations of phosphate values and average numbers of macroplankton (N 100 H) at stations in South Georgia survey of December–January 1926–7

Phosphate mg./m.^{3}, average 0–50 m. depth	> 105	100·5–105	95·5–100	90·5–95	85·5–90	< 85
Number of stations averaged	6	7	8	11	8	5
Number of night stations included	2	1	4	5	3	1
Number of deep-water stations included	4	1	5	4	1	0
Eukrohnia hamata	6	5	47	**71**	**144** (45[a])	4
Calanus simillimus	3	9	**13**	8	3	1
C. propinquus	171	210	674	**959**	319	169
C. acutus	5	5	87	268	294	**360**
Rhincalanus gigas	159	95	325	693	**815**	301
Pareuchaeta antarctica	27	9	**234**	105	35	38
Parathemisto gaudichaudi	14	96	**249** (**119**[b])	63	45	36
Primno spp.	2	1	2	**3**	2	0
Vibilia antarctica	4	6	**21**	10	4	1
Antarctomysis antarctica	1	16	0	**365**	**390**	171
Euphausia superba, adult	**7157** (74[c])	932	**2176**	445	38	2
E. superba, larvae	0	0	**1**	0	0	0
E. frigida, adult	38	20	**72**	43	13	0
E. frigida, larvae	3	0	42	**146**	13	6
Thysanoessa spp., adult	82	26	111	94	**141**	12
Thysanoessa larvae ..	2	15	20	**166**	2	28
Limacina helicina	5	51	**239**	**547** (122[d])	47	40
Salpa fusiformis	188	190	**2129**	**1243** (284[e])	193	1

[a] Excluding one outstanding catch of 840.
[b] ,, ,, ,, ,, 1,157.
[c] ,, ,, ,, ,, 42,500.
[d] ,, ,, ,, ,, 4,800.
[e] ,, ,, ,, ,, 10,835.

The results of these two series are tabulated in Table LV. They both give a fair confirmation of the results shown in Table LIV. What is more important is that split into separate day and night series they represent two quite independent sets of observations divided by no artificial means, and the one set in general confirms the other. *Euphausia superba* in both day and night series has its highest average numbers in the highest range of phosphate values (in the night series one of these is due to an exceptionally high catch which if omitted still places the highest average number in the highest phosphate range). *Pareuchaeta* and *Parathemisto* in the night series also have their highest average numbers in the highest range of phosphate values. The only species which have their highest average numbers in the lowest phosphate values in addition to *Calanus acutus*, *Rhincalanus* and *Antarctomysis* (already noted in Table LIV) are the copepod *Pareuchaeta antarctica*, in daylight series only (and with small numbers) and the chaetognath *Eukrohnia hamata*. The figures for the latter are, however, upset by one outstanding catch, as shown in the footnote to Table LV. The two copepods *C. acutus* and *R. gigas* will be dealt with when we come to consider the copepods in greater detail in the results of the N 70 V and N 70 H nets. We will, however, here deal with the exception *Antarctomysis maxima*.

Table LV

Correlations of phosphate values and average numbers of the same macroplankton organisms given in Table LIV, but divided into stations taken in daylight and those taken in darkness

	Stations taken in daylight			Stations taken in darkness		
Phosphate mg./m.^{3}, average 0–50 m. depth	> 100	90–100	< 90	> 97 (98–113)	92–97	< 92 (78–91)
Number of stations averaged	10	10	9	6	5	5
Number of deep-water stations included	3	3	0	4	3	2
Eukrohnia hamata	2	**51**	36	39	**81**	**180** (16[a])
Calanus simillimus	5	6	3	10	**19**	4
C. propinquus	123	**668**	170	703	**1323**	408
C. acutus	5	**252**	**245**	28	193	**382**
Rhincalanus gigas	104	**690**	350	226	500	**984**
Pareuchaeta antarctica	2	**28**	**31**	**325**	131	107
Parathemisto gaudichaudi	22	**57**	28	**344** (**181**[b])	94	82
Primno spp.	2	**3**	1	0	**2**	0
Vibilia antarctica	**5**	**5**	1	10	**37**	7
Euphausia superba, adults	**321**	**275**	10	**9364** (**2737**[c])	1833	118
E. superba, larvae	0	0	0	1	1	0
E. frigida, adults	1	**3**	0	102	**145**	30
E. frigida, larvae	1	**103**	5	43	**135**	18
Thysanoessa spp., adults	29	30	30	97	**282**	193
Thysanoessa larvae	11	**155**	14	28	**53**	8
Limacina helicina	35	**216**	20	62	**1082** (**152**[d])	87
Salpa fusiformis	134	**222**	3	568	**3683** (**1896**[e])	420
Antarctomysis maxima	12	**253**	**116**	0	**297**	**563**

[a] Excluding one outstanding catch of 840.
[b] ,, ,, ,, ,, 1,157.
[c] ,, ,, ,, ,, 42,500.
[d] ,, ,, ,, ,, 4,800.
[e] ,, ,, ,, ,, 10,835.

We see that this mysid *Antarctomysis maxima* occurs at stations having a lower phosphate value and so a higher phytoplankton concentration than do the other organisms. We have seen in the detailed discussion of its occurrence on p. 201 and in Fig. 88 that it has a most interesting distribution in that it is directly the reverse of that of *Euphausia superba*, being concentrated on the south-west side of the island, i.e. in the region of dense phytoplankton production. This is a form which rarely comes into the surface layers; it lives near the bottom during the day and usually only comes into midwater depths during the night. It rarely swims into the zone of actual rich phytoplankton in the upper 50 m., but living below the phytoplankton will likely benefit by the falling rain of food without either bringing about a reduction of the phytoplankton above or from the opposite point of view suffering exclusion from the concentrations well above it.

Now, whilst we saw on p. 230 that the zooplankton communities of the regions occupied by different water masses and having different phytoplankton concentrations were in general very much the same, we saw that certain forms, e.g. *Euphausia superba*, *Limacina helicina* and *Salpa fusiformis*, were more characteristic of the Weddell Sea water than of the Bellingshausen Sea water and the area of mixture (Group II) on the west of the island. We know too that there was a greater phytoplankton production and a greater reduction in phosphates on the western side of the island than on the eastern side. It might be that the general correlations between zooplankton and reduced phosphate content, and so phytoplankton, could be accounted for simply by the differing content of these water masses. Indeed, as referred to on p. 277, this at first seems likely; but we have reserved a consideration of this point until the present juncture, because it is possible to show that *within* each of the groups of stations concerned, in spite of the patchiness of the plankton and the small number of stations averaged, there is in general the same sorting out of the zooplankton in relation to phosphate values. This is shown in Table LVI. The groups of stations II, III and IV are the groups of stations having a characteristic phytoplankton; they are discussed on pp. 69 to 72 and again in relation to zooplankton on p. 230.

We will now turn to the results of the N 70 V and N 70 H nets, the nets used for the capture of the smaller zooplankton species. We will take the N 70 V nets first. These nets it will be remembered were fished vertically, when the depth allowed it, in a series of hauls from 1000 m. to the surface: 1000–750, 750–500, 500–250, 250–100, 100–50 and 50–0 m., the nets being closed at the end of each range of depth. We will consider only the hauls for the top 250 m. and express the numbers of organisms as an average per 50 m. haul, because at some stations the depth of water did not allow of a full 250 m. range being taken. The stations are grouped and averaged for the same ranges of phosphate values as used for the N 100 H nets and the results are tabulated in Table LVII. The organisms which occur in numbers sufficient for the calculations are largely Copepoda. We may conveniently consider the other organisms first; they are those shown in the first group in the table. The Foraminifera, the Radiolaria and the polychaete *Pelagobia longicirrata* show an optimum concentration at the range of phosphate values of 90–100 mg. per m.^{3} In the case of the chaetognath *Eukrohnia hamata* no such optimum concentration is shown, but the numbers involved are very small; nevertheless we shall see later that this exception is possibly significant.

The Copepoda at first sight appeared to present difficulties and to give results conflicting with those found for the macroplankton organisms in Table LIV. However, we may divide them into three categories, which we will call Groups *A*, *B* and *C*. Those in Group *A* appear to follow the general principle. Those in Group *B*, *Calanus acutus*, *Rhincalanus gigas* and *Oithona similis*, show little or no correlation with the phosphate

Table LVI

Correlations of phosphate values and the average numbers of macroplankton (N 100 H) at stations in phytoplankton Groups II, III and IV. For further explanation see text

Phosphate mg./m.^{3}, average 0–50 m. depth...	> 105	100·5–105	95·5–100	90·5–95	85·5–90	< 85
Stations in phytoplankton. Group II, number of stations averaged ...	—	1	—	1	3	1
Parathemisto gaudichaudi	—	6	—	24	**45**	9
Euphausia superba	—	0	—	**6**	1	3
E. frigida	—	0	—	0	1	2
Thysanoessa spp.	—	8	—	**566**	72	25
Limacina helicina	—	4	—	22	**111**	3
Salpa fusiformis	—	0	—	**54**	2	0
Stations in phytoplankton. Group III, number of stations averaged ...	4	4	3	3	2	—
Parathemisto gaudichaudi	8	**152**	57	67	39	—
Euphausia superba	**10,630** (6[a])	1856	**2174**	1181	43	—
E. frigida	53	35	106	**142**	0	—
Thysanoessa spp.	70	40	**208**	36	73	—
Limacina helicina	4	45	**133**	**181**	11	—
Salpa fusiformis	68	194	**1981**	**724**	3	—
Stations in phytoplankton. Group IV, number of stations averaged ...	—	2	4	5	2	2
Parathemisto gaudichaudi	—	29	**390**	45	73	56
Euphausia superba	—	0	**2630**	95	2	0
E. frigida	—	1	**42**	5	0	0
Thysanoessa spp.	—	6	**50**	**68**	13	5
Limacina helicina	—	88	**379**	**1083**	10	51
Salpa fusiformis	—	276	**679**	**2286**	11	1

[a] Excluding one outstanding high catch of 42,500 at St. WS 26.

values. Of the two species we include in Group *C Calanus simillimus* has an optimum concentration at phosphate value 85·5–90 mg. per m.^{3} and so appears to be correlated with a higher phytoplankton concentration than those we have included in Group *A*, whereas *Drepanopus pectinatus* appears to be correlated with a very low phosphate content and so a very high phytoplankton concentration. Before discussing the Copepoda further we will see if these results are confirmed from the N 70 H series of nets.

The N 70 H nets, it will be remembered, were towed horizontally at each station like the N 100 H nets, but for a distance of a quarter of a mile only. Three nets were towed together, one near the surface, one at a depth of approximately 75–50 m. and one at a depth of approximately 150–100 m. The two lower nets were closed, like the N 100 H

Table LVII

Correlations of phosphate values and the average numbers of the more important plankton organisms taken in N 70 V nets for the top 250 m., expressed as averages per 50 m. haul

Phosphate mg./m.^{3}, average 0–50 m. depth	> 105	100·5–105	95·5–100	90·5–95	85·5–90	< 80
Number of stations averaged	6	7	8	11	8	5
Number of deep-water stations included	4	1	5	4	1	0
Foraminifera	38	369	**591**	**518**	38	120
Radiolaria	17	35	**48**	12	30	0
Eukrohnia hamata	8	9	6	8	7	4
Pelagobia	3	26	**61**	**79**	37	53
Copepoda, Group *A*						
Calanus propinquus	13	46	**69**	**65**	34	51
Clausocalanus laticeps	3	9	**27**	9	4	1
Ctenocalanus vanus	168	**375**	**324**	250	168	**468** (218[a])
Pareuchaeta antarctica	2	0	**5**	**5**	2	3
Scolecithricella minor	**19**	10	**15**	**17**	9	2
Pleuromamma robusta	0	0	0	2	0	0
Metridia gerlachei	8	0	**13**	**17**	5	7
Metridia lucens	2	20 (2[b])	**13**	6	2	14 (1[c])
Copepoda, Group *B*						
Calanus acutus	11	243	208	147	90	301
Rhincalanus gigas	21	27	13	29	21	11
Oithona frigida	1847	1706	2590	2291	1609	2003
Copepoda, Group *C*						
Calanus simillimus	2	13	11	22	**35**	14
Drepanopus pectinatus	1203	307	369	**2614**	**2041**	**5900**

[a] Omitting one outstanding high catch of 1468 at St. WS 45.
[b] „ „ „ „ 129 at St. 136.
[c] „ „ „ „ 71 at St. WS 45.

nets, at the end of their tow before being hauled to the surface. As in dealing with the N 100 H nets, we will take the total numbers of each organism taken at each station in the three nets. The stations are arranged and averaged in groups of the same ranges of phosphate values as before. The samples obtained by these nets were analysed by the late Mr Andrew Scott, who was particularly interested in the Copepoda. The only organisms he identified specifically other than copepods were the amphipods *Parathemisto gaudichaudi* and *Salpa fusiformis*; these, together with *Euphausia* spp. adults and *Euphausia* spp. larvae are included with the Copepoda in Table LVIII. We will take the Copepoda first. Here we see a striking confirmation of the three categories suggested in the N 70 V net results. All those of Group *A* conform to the principle. Those of Group *B* show little or no correlation, and *Calanus simillimus* and *Drepanopus pectinatus* in Group *C* show the same relation to the phosphate values (and so to the

Table LVIII

Correlations of phosphate values and the average numbers of the more important Copepoda and a few other organisms, taken in the N 70 H nets[1]

Phosphate mg./m.^{3}, average 0–50 m. depth	> 105	100·5–105	95·5–100	90·5–95	85·5–90	< 80
Number of stations averaged	6	7	8	11	8	5
Number of night stations included	2	1	4	4	3	1
Number of deep-water stations included	4	1	5	4	1	0
Copepoda, Group *A*						
Calanus propinquus	238	339	**771**	294	302	**1,465** (245[a])
Clausocalanus laticeps	31	148	**509**	181	125	92
Ctenocalanus vanus	1,220	2,227	**5,563**	3,586	3,966	2,700
Pareuchaeta antarctica	31	18	**49**	32	23	16
Scolecithricella minor	43	12	**46**	37	6	5
Pleuromamma robusta	41	37	**51**	0	9	0
Metridia gerlachei	59	**185**	**96**	73	60	15
Metridia lucens	32	**169**	**180**	**165**	35	38
Copepoda, Group *B*						
Calanus acutus	45	565	1,826	1,002	1,295	1,836
Rhincalanus gigas	324 (74[b])	161	122	144	309 (142[c])	92
Oithona frigida	29,158	38,404	230,546 (54,717[d])	76,757	82,415	75,408
Copepoda, Group *C*						
Calanus simillimus	128	774	**1,361** (549[e])	407	**1,306**	**1,582** (349[f])
Drepanopus pectinatus	1,019	537	1,131	12,532	**95,297**	**494,925**
Macroplankton						
Parathemisto gaudichaudi	11	**103**	70	25	**178** (45[g])	16
Euphausia spp., adult	100	**1164**	**292**	108	161	0
Euphausia spp., larvae	413 (38[h])	276	**814**	475	149	192
Salpa fusiformis	68	80	**145**	82	28	18

[a] Omitting one outstanding high catch of 6,345 at St. WS 42.
[b] ,, ,, ,, ,, 1,575 at St. WS 26.
[c] ,, ,, ,, ,, 1,490 at St. 124.
[d] ,, ,, ,, ,, 1,461,352 at St. 138.
[e] ,, ,, ,, ,, 7,042 at St. 128.
[f] ,, ,, ,, ,, 6,515 at St. WS 42.
[g] ,, ,, ,, ,, 1,110 at St. WS 34 (phosphate value = 89).
[h] ,, ,, ,, ,, 2,336 at St. 151.

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[1] The N 70 H samples were treated in detail for Copepoda, but only a few of the other species were identified.

phytoplankton) as before. The other organisms, *Parathemisto*, *Euphausia* spp. adult and larvae, and *Salpa fusiformis*, give a confirmation of the N 100 H results.

Now in this series of N 70 H nets, towed horizontally and not covering the complete range of diurnal vertical migration of some of the species, we again come against the difficulty of there being a higher proportion of night stations in the range of phosphate values between 90 and 100 than those above 100 or below 90. We can again divide them into two series, one of daylight stations and one of night stations (taken between sunset and sunrise).[1] Whilst we can take the same ranges of phosphate values in the daylight stations as those in the daylight N 100 H stations, in the night stations, because the times of the N 70 H nets differed slightly from those of the N 100 H, we must take slightly different phosphate ranges to give an equal number of stations in each range. We take the ranges above 98, 92–98 and below 92 (instead of above 97, 92–97 and below 92 as in the N 100 H), giving five stations in each range. The results are tabulated in Table LIX.

The daylight series gives a confirmation for each organism except *Salpa*, which is known to be patchy, and is too large an organism to be caught adequately in the N 70 H nets. The night series gives a 71 per cent confirmation, including that for *Salpa*, the exceptions not being in the range of low phosphate values (i.e. high phytoplankton) but the reverse. Again, what is still more important is that the two series of day and night stations offer two sets of quite independent results, one in general confirming the other.

The results are interesting in that they suggest that our methods in the field sampled the plankton very much more accurately than we had believed possible, in view of the patchiness of some of the organisms. It is gratifying too that the methods of laboratory analysis appear to have been adequate. It is perhaps worthy of mention that these results which confirm each other have been obtained by three different workers—Mr E. R. Gunther analysed the N 70 V nets, Mr Andrew Scott the N 70 H nets, and Dr Helène Bargmann the N 100 H nets.

The working out of the zooplankton results in respect to the N 70 nets of later surveys has not gone far enough yet to offer any material for comparison, but Dr Mackintosh has now completed the analyses of the N 100 nets for a number of later surveys, and his results have recently been published (1934). At my request he kindly plotted the more important organisms against ranges of phosphate values in the South Georgia surveys of the seasons 1928–9, 1929–30 and 1930–1. The curves resulting from these correlations show that in general there is a good degree of confirmation of our results; but in a number of instances confirmation appears to be only moderate or lacking, a closer analysis of the data must be undertaken before it is possible to speak with certainty.

In considering the results of these later surveys in relation to the one at present under discussion it is necessary to note that an important change was made in the methods in

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[1] This has not been done in the case of the N 70 V nets (Table LVII) because, except for the deeper water species which occur in too small numbers to be so divided, the vertical nets cover the migration range of the different species.

Table LIX

Correlations of phosphate values and the same organisms as given in Table LVIII, but divided into stations taken in daylight and stations taken in darkness

	Stations taken in daylight			Stations taken in darkness		
Phosphate mg./m.^{3}, average 0–50 m. depth	> 100	90–100	< 90	> 98	92–98	< 92
Number of stations averaged	10	11	9	5	5	5
Number of deep-water stations included	3	4	0	4	2	2
Copepoda, Group *A*						
Calanus propinquus	162	**370**	186	**846**	601	**1,664** (494^{a})
Clausocalanus laticeps	51	**189**	132	**443**	**395**	152
Ctenocalanus vanus	647	**3,022**	2,822	5,047	**8,301**	4,082
Pareuchaeta antarctica	1	**27**	17	67	**82**	21
Scolecithricella minor	2	**15**	5	76	**113**	3
Pleuromamma robusta	1	0	1	**102**	79	12
Metridia gerlachei	4	2	**48** (0^{j})	287	**310**	63
M. lucens	2	**5**	2	**510**	399	117
Copepoda, Group *B*						
Calanus acutus	684	1,510	797	968	2,382	2,566
Rhincalanus gigas	143	164	246 (90^{c})	331 (16^{b})	150	168
Oithona frigida	19,895	182,579 (54,702^{d})	86,583	56,733	144,126	51,616
Copepoda, Group *C*						
Calanus simillimus	286	**886** (270^{e})	**705**	935	781	**2,473** **(1,462^{f})**
Drepanopus pectinatus	906	12,809	**32,229**	938	1,172	**589,395**
Parathemisto gaudichaudi	24	23	24	**188**	17	457 (44^{g})
Euphausia spp., adult	34	**103**	7	**1705**	288	275
Euphausia spp., larvae	319 (83^{h})	**570**	83	561	**844**	299
Salpa fusiformis	**56**	22	2	104	**221**	164

[a–h] Omitting outstanding high catches shown under Table LVIII.
[j] ,, one catch of 240 at St. 124.

the field, so that at each N 100 station in all later surveys instead of three N 100 H nets being towed simultaneously for a mile—one near the surface and two at lower levels of approximately 50–75 m. and 100–150 m.—only one net was used, lowered to approximately 100 or 150 m. and hauled *obliquely* to the surface whilst the ship travelled two-thirds of a mile. Thus at each station in our surveys three miles of water were sampled as against just over two-thirds of a mile in later surveys, i.e. $4\frac{1}{2}$ times the quantity. By the experiments with series of consecutive nets we have shown that the patchiness of some of these macroplankton organisms, particularly Euphausians, is such that one haul of half a mile may often miss a patch altogether, whereas two consecutive hauls (or a tow of one mile) will stand a good chance of sampling part of such a patch. For the results of these later surveys to be comparable with our own they should contain 4½ times as many stations in the same area; actually they contain about the same number. It is not our intention here to be critical of the change in procedure adopted, a change which was designed to enable extensive areas to be charted more rapidly than by the old method, but to point out that when making comparisons between later surveys and the one now under review we must not be surprised if we do not find a high degree of confirmation. It is noteworthy that the failure of confirmation is most marked in the Euphausians, which we have shown to be very patchy in their distribution.

The correlations between the zooplankton taken in the different series of nets and the phosphate values appear to lend strong support to the conception that it is the phytoplankton which is influencing the distribution of the majority of the plankton animals rather than that it is these animals which by grazing are controlling the phytoplankton. If the latter is true, how is it that so many different animals have the same type of correlation with the phosphate values? The species which occur in relatively small numbers could only have a negligible effect upon the phytoplankton compared with the abundant species, yet these rarer species show the same type of correlation as do those which are very abundant. For the majority of species it appears that their distribution must either be governed by the phytoplankton or by some other factor unknown, which brings them together so that they have the appearance of combining together to control the phytoplankton. It is possible that one outstanding species, or perhaps a few such species together, may be controlling the phytoplankton, and that the pattern of phytoplankton so produced—areas of high and low concentrations—may be in turn influencing the distribution of the majority of less abundant animal species. From a re-examination of the data made in the light of Harvey's (1934) investigations and to be discussed presently, it does actually appear likely that *Euphausia superba* may be a key zooplankton organism which is at any rate in part controlling the phytoplankton, and that the other organisms are in turn having their distribution adjusted by that of the phytoplankton.

Another point must be mentioned here. All the animals which are correlated with the phosphate values are reacting to phytoplankton production generally; we do not know that they are feeding indiscriminately upon all the phytoplankton equally—it is most unlikely—and some of the forms are certainly carnivorous. We should expect some herbivorous animals to govern the abundance of only some species of the phytoplankton, and other herbivorous animals to govern only other species. Actually we see the same correlations between phosphate values and the same series of animals applying in regions of different phytoplankton floras, as shown in Table LVI. For this reason, granted that it is possible or even likely that *Euphausia superba* may be governing the phytoplankton in some regions, it is likely that this Euphausian will not be governing it in all regions, and that it too may be excluded from areas of dense phytoplankton which it cannot keep in check. As Harvey in writing to me has said, the two principles are not antagonistic.

We must now see if the division of the Copepoda into the three groups *A*, *B* and *C*, having different types of correlation with the phosphate values, can be linked with any phenomenon seen in our survey; such a linkage might be expected to throw important light on the problem of this correlation with phosphates and so with phytoplankton production. As soon as it appeared to be possible that the zooplankton distribution was being governed by the phytoplankton it became necessary to consider how they would be displaced away from areas of dense phytoplankton production. The increase of numbers in regions of moderate phytoplankton and their decrease in regions of high production cannot be due to actual multiplication and mortality, for many of these plankton forms must take a considerable period to reach maturity in these cold latitudes. It has been shown that *Euphausia superba* probably takes two years (Ruud, 1932).[1] Two possible methods were considered: firstly that of actual horizontal migration by swimming, and secondly that of vertical migration away from the upper layers and remaining down until carried by currents, different in speed or direction from the surface currents, out of the region of exclusion. We had seen Euphausians in the fjords swimming round and round in dense swarms for long periods (see p. 210), and it seemed possible that if the necessity arose they might be able to swim in a straight line away from a region of exclusion. At first when *Euphausia* alone was being considered this view was favoured, but Dr Kemp, with whom I discussed this problem, was of the opinion that this was not possible and that the second method must be the correct one. The subsequent investigation of the large number of different species, the results of which have been given above, show that he was right. The smaller members of the zooplankton, the Copepoda, the Pteropoda, to say nothing of the Foraminifera, obviously could not make such swimming migrations; yet our results suggest that they have the power of distributing themselves horizontally in relation to the phytoplankton production in the upper layers. The power of vertical migration which so many of these organisms possess would seem to be their means of "navigation". They rise towards or into the phytoplankton zone during the night and fall away from it during the day. It is suggested that the greater the phytoplankton concentration the deeper, *or possibly for a longer time*, will the zooplankton organisms penetrate into the layers below, and since the surface currents differ in speed and sometimes in direction also from those below, the organisms will be carried gradually away from the zone of high phytoplankton concentration. Similarly, according to this hypothesis, if the concentration is less dense the zooplankton organisms would not show such a marked migration away from the upper layers and so would remain in that body of water. It would appear that they may be travelling just as balloonists do when they make use of the air currents going in different directions at different heights. The balloonist is aerially "planktonic"—a passively drifting creature, but one who can migrate vertically up or down by liberating either ballast or gas. The "navigation" of the marine plankton organisms would be no doubt an automatic one. The data were now re-examined for any evidence for or against this hypothesis.

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[1] And shown independently by Wheeler, but data not yet published, see p. 215.

Fortunately we made a sufficient number of observations to determine broadly the relative powers of vertical migration of the more important plankton forms within the area, and in order to follow the discussion frequent reference should be made to the special section devoted to the subject (pp. 231 *et seq.*), and details of the vertical migration studied in the graphs which illustrate it. We see that each of the macroplankton species which showed in its horizontal distribution smaller numbers in areas of greater phytoplankton production showed also a marked vertical migration: i.e. all the Euphausians and their larvae, the amphipods *Parathemisto*, *Primno* and *Vibilia*, the pteropod *Limacina helicina* and the tunicate *Salpa fusiformis*. The behaviour of the different copepods is of special interest. We saw that in their horizontal distribution in relation to the phytoplankton (indicated by phosphate values) we could divide the Copepoda into three categories, Groups *A*, *B* and *C*. Those in Group *A*, *Calanus propinquus*, *Clausocalanus laticeps*, *Ctenocalanus vanus*, *Pareuchaeta antarctica*, *Scolecithricella minor*, *Pleuromamma robusta*, *Metridia gerlachei* and *M. lucens*, were all fewer in the zones of greater phytoplankton production, as were the macroplankton organisms just mentioned, and we see that all these forms have also a marked vertical migration. In Group *B* we placed *Calanus acutus*, *Rhincalanus gigas* and *Oithona frigida*, copepods which showed little or no correlation with phytoplankton concentrations. They are forms which are less frequently found in the upper 50 m., and they *show little or no vertical migration* (see Figs. 108 to 113).[1] Not only does this mean that they may be almost indifferent to the phytoplankton concentrations above them, but that if the hypothesis is correct they will have usually no means of "navigation", and it is noteworthy that it is just these three forms which we find to have the most uniform distribution of any of the Copepoda (see Figs. 63, 67 and 84). We have said "*almost* indifferent to the phytoplankton" and "*usually* no means of navigation", because presently we shall see that in cases of extreme phytoplankton production they may be influenced.[2] In the third group of Copepoda we placed *Calanus simillimus*, which "prefers" a high concentration of phytoplankton but avoids extreme quantities, and *Drepanopus pectinatus*, which so far as our investigations go "prefers" and flourishes in the highest phytoplankton concentration met with. Whilst these two species show a marked vertical migration, they differ from the other Copepoda *in coming to the surface a long time before any of the others do and remaining at the surface longer* (see Figs. 99 and 100). Just as they occur in higher concentrations of phytoplankton than do the other forms, so do they enter the phytoplankton zone before the others do so. The only macroplankton animal which we observe having a vertical migration approaching that of these two copepods is the carnivorous amphipod *Parathemisto gandichaudi* (Fig. 121); but its arrival at the surface in large numbers is some two hours later in the evening. It is interesting to notice that the modes of the curves of vertical migration of a number of species balance at a point in time later than midnight. Whilst this might be due to the time taken for these species to reach the surface, it might also suggest that it may possibly be due to the time taken in the dissipation of some harmful influence produced by the phytoplankton in the surface layers during the hours of daylight.

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[1] Mackintosh (1934) confirms this lack of vertical migration in *Calanus acutus* and *Rhincalanus gigas*; he does not, however, deal with *Oithona frigida*.

[2] With these three copepods we might place the chaetognath *Eukrohnia hamata*, for this species, whilst showing a moderate correlation with medium phosphate value in the N 100 H samples, showed no such correlation in the N 70 V nets; it also shows very little vertical migration, is only rarely taken at the surface and is very evenly distributed. The numbers however in the N 70 V nets were small; more information is required regarding this species.

These facts support the hypothesis that vertical migration is bound up with the principle of animal exclusion. We see that the animals fall into the same groups in relation to the two phenomena, suggesting that the former is likely to be concerned with the latter, in that the correlation or non-correlation of the distribution of the zooplankton with that of the phytoplankton (indicated by phosphates) is likely to be brought about through the presence or absence of vertical migration. The process of vertical migration then appears likely to be the means by which these passively drifting organisms are distributed in relation to phytoplankton. For this to be so it is clear that the extent of the vertical migration must vary according to the concentrations of the phytoplankton, otherwise no such horizontal distribution in relation to the phytoplankton would be possible. This will be further discussed in the next section.

Table LX

Correlations of the more important species of Copepoda[1] *on the "G" line of the South Georgia survey, January 1927, with phosphate values and phytoplankton expressed in millions of cells*

Stations	WS 63	WS 51	WS 50	WS 49	WS 48	WS 47	WS 46
Phytoplankton millions ...	2·6	0·58	6·1	**531·2**	**502·5**	126·1	0·9
Phosphate mg./m.^{3}, average 0–50 m. depth	99·5	90·5	86	74	88	86	92
Calanus simillimus	9	*2*	66	12	*7*	*4*	*2*
C. propinquus	66	30	108	*23*	*10*	33	51
C. acutus	499	291	*44*	*27*	*17*	135	176
Rhincalanus gigas	9	9	*3*	*3*	*1*	14	7
Ctenocalanus vanus	565	290	173	*61*	*15*	205	*70*
Scolecithricella minor	56	22	12	*3*	*0*	*2*	*5*
Metridia gerlachei	8	4	3	21	*0*	*2*	*1*
M. lucens	*0*	7	*1*	2	*1*	4	8
Oithona frigida	3055	2649	1560	*1480*	*1095*	2038	1663
Drepanopus pectinatus	*267*	*468*	1395	**3642**	**4318**	1622	*263*

[1] The Copepoda are those taken in the N 70 V nets expressed as number per 50 m. haul for the top 250 m.

Numbers of organisms shown in *italics* are those which are less than half the average of the values for all the stations on the line, except for *Oithona frigida* where they are less than approximately three-quarters of the average, there being none less than a half.

At two stations in the South Georgia survey we had a phytoplankton concentration considerably greater than at any other station—viz. Sts. WS 48 and 49. These were on the "G" line running out from the west of the island. The distribution of the more important species of Copepoda on this line is shown in Table LX. We see that even the forms which usually show an indifference to the phytoplankton—*Calanus acutus*, *Rhincalanus gigas* and *Oithona frigida*—here are taken in smaller numbers in the region of high concentration. *Drepanopus pectinatus* alone appears to flourish under these conditions. Perhaps if the concentration was still higher *Drepanopus* itself would be affected.

On the publication of Harvey's (1934) paper stressing the control of the phytoplankton by grazing I went over all the data again in order to see if I could find a fallacy in this apparent close linkage between the vertical migration of the zooplankton and its distribution in relation to phytoplankton.[1] Whilst all the horizontal nets were fished at approximately comparable depths, and in the case of the vertical nets only the top 250 m. of water were considered, I found that I had not taken into account the possible effect of there being a greater depth of water below the ranges sampled at some stations than at others. We have seen that the only common forms of zooplankton in our survey which make little or no vertical migration are forms which are rarely found in the upper phytoplankton zones. The forms which might control the phytoplankton by grazing are those which make vertical migrations; thus the main grazing effect would take place at night. Now as the ocean currents approach the shallower regions it might be expected that there would be a gradually reduced number of animals in the upper layers at night, because there is a smaller body of water below from which they can rise; the larger body of water containing more animals in the daytime is continually being carried away to one side or the other. This principle is shown in Fig. 168. It will be remembered that more of our deep-water stations were night stations than were our shallow-water stations; thus it appeared possible that the conclusions drawn from the correlations shown above might be fallacious, since we saw that we had more night stations in the intermediate ranges of phosphate values than in others. In the above Tables LIV–LIX I have put in the number of deep-water stations—those of a depth of

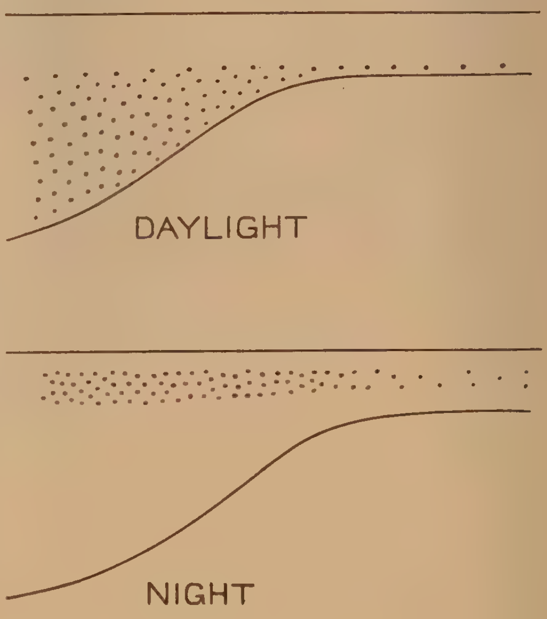

Fig. 168.

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[1] We must recognize, as Harvey himself does, that his observations are extensive in time but not in space, that bodies of water varying in their phyto- and zooplankton content move past his line of observation, and that the phytoplankton crop in the Plymouth area is likely to be very much less than that in the Antarctic.

over 500 m.—in each range of phosphate values. Such considerations would not invalidate the correlations with the phosphate values, and so with phytoplankton, but might indicate that the depth of water below the phytoplankton zone was indeed such a factor as that which we had conceived might be making a large number of zooplankton organisms appear to be combining together to keep a check on the phytoplankton.

Table LXI

Showing the average numbers of the more important macroplankton organisms taken in the series of three N 100 H nets at each daylight station; the stations being arranged in order of decreasing soundings from deep to shallow water

Soundings in metres	Station	*Euphausia superba*	*Euphausia frigida*	*Thysanoessa* spp.	*Parathemisto gaudichaudi*	*Salpa fusiformis*	*Limacina helicina*
3200	151	316	0	96	39	252	1
2530	138	581	0	35	90	208	497
1470*	WS 44	0	1	4	33	131	129
1242	WS 36	25	0	11	68	390	279
740	137	284	16	33	148	1385	690
614	WS 29	14	0	63	17	217	0
318	WS 37	0	0	8	24	420	46
248	WS 28	2	0	1	7	0	0
243	135	82	0	32	31	0	8
240	131	806	1	36	16	2	399
237	WS 39	762	0	13	19	58	109
230	WS 50	0	0	18	1	0	5
224	WS 48	3	2	31	13	0	32
223	WS 49	3	2	25	9	0	3
220	124	4	0	114	46	5	13
210	WS 51	0	0	15	2	3	3
184	WS 52	0	0	8	6	0	4
183	WS 40	179	0	32	28	202	141
180	132	2109	0	94	65	261	48
180	WS 45	0	0	0	89	0	35
176	134	243	19	14	142	2	7
167	128	0	0	113	16	16	106
157	127	0	2	3	16	0	3
140	WS 41	0	0	22	6	0	16
135	WS 33	0	0	9	23	1	66
122	130	633	0	9	39	13	33
100	126	3	8	6	5	0	11
80	WS 27	2	0	0	0	0	0
76	WS 31	4	0	23	38	17	4

* Bottom not reached.

In Tables LXI to LXIV are shown the average numbers of the more important macroplankton organisms taken in the series of three N 100 H nets, and of the smaller animals taken per 50 m. haul in the top 250 m. in the N 70 V nets, arranged in order of decreasing soundings; each is divided into two series of stations, those taken in daylight and those taken at night. In the daylight macroplankton series, Table LXI, we have only six deep-water stations (i.e. over 500 m.), and out of the six more important organisms shown only *Salpa* and *Limacina* show notably more frequent occurrence over deep water. In the night series, Table LXII, nine out of the sixteen stations have a depth of over 500 m., and here we see a considerable difference in the numbers taken over deep water in the case of *Euphausia superba*, *E. frigida*, *Salpa fusiformis* and to a lesser extent *Thysanoessa* spp. The grazing effect of some of the macroplankton must indeed be heavier over the deep water than in shallow water. The principle, illustrated in Fig. 168, must thus be one of some ecological importance. In Tables LXIII and LXIV showing the smaller animals, particularly the Copepoda, we notice only a few significant differences between deep- and shallow-water stations, e.g. Foraminifera in the daylight but not the night series, the deep-water Copepoda *Scolecithricella minor* and *Metridia gerlachei* in both series. The neritic nature of *Drepanopus pectinatus* is clearly shown.

Table LXII

Showing the average numbers of the more important macroplankton organisms taken in the series of three N 100 H nets at each night station; the stations being arranged in order of decreasing soundings from deep to shallow water

Soundings in metres	Station	*Euphausia superba*	*Euphausia frigida*	*Thysanoessa* spp.	*Parathemisto gaudichaudi*	*Salpa fusiformis*	*Limacina helicina*
3230	139	372	41	22	128	577	37
3140*	125	2,365	385	51	124	1,592	108
2582	WS 30	212	107	768	2	1,514	4
2201	WS 61	108	16	115	12	612	12
2103*	WS 38	172	16	56	105	10,835	190
1752	WS 63	372	96	76	196	1,168	0
1180	WS 26	42,500	205	209	3	50	5
1001	129	6,522	316	508	195	5,929	290
802	133	9,653	145	101	1157	940	157
246	136	3,552	139	53	526	458	24
200	WS 43	101	8	227	22	9	4800
194	WS 46	6	0	566	24	54	22
175	WS 42	6	0	5	54	5	82
161	WS 35	0	0	30	170	182	172
160	WS 47	0	0	166	122	2	296
121	WS 34	0	0	3	108	4	16

* Bottom not reached.

It is necessary to consider this matter in detail because it does appear at first sight that here is a possible alternative explanation of some of the phenomena we have observed. We must once again see if there are correlations with phosphate values, but this time split the series into shallow- and deep-water stations. Let us consider the N 100 H nets first. In the shallow-water series we have eight stations in water of phosphate value > 100 mg. per m.^{3}, one of which is a night station, ten stations in water of phosphate value 90–100 mg., three of which are night stations, and twelve stations in water of phosphate value < 90 mg., three of which are night stations. Here we can include the night stations, since there are as many in the low phosphate range as in the intermediate. In the deep-water series there is only one station of phosphate value below 90 mg.

(a night station), nine stations of phosphate value of 90–100 mg., six of which are night stations, and five stations in phosphate value of > 100 only two of which are night stations. If we consider the night stations only we can divide them into three sets of three stations each having phosphate ranges of 113–100, 99–95 and 92–86. The small number of stations is unsatisfactory, but if the distribution of a number of different species within these three sets of three stations gives some degree of consistency, then it may be better than nothing. In Table LXV the two sets of data, for shallow water and for deep water (night stations only), are set out in respect of the vertically migrating plankton: Macroplankton and Copepoda Groups *A* and *C*. Few though the data are in respect to deep-water

Table LXIII

owing the zooplankton organisms, expressed as numbers per 50 m. haul, taken in the top 250 m. (or less according to depth of sounding) by the N 70 V nets at each daylight station; the stations being arranged in order of decreasing soundings from deep to shallow water

						Copepoda Group *A*								Copepoda Group *B*			Copepoda Group *C*	
oundings in metres	Station	Foraminifera	Radiolaria	*Eukrohnia hamata*	*Pelagobia*	*Calanus propinquus*	*Clausocalanus laticeps*	*Ctenocalanus vanus*	*Pareuchaeta antarctica*	*Scolecithricella minor*	*Pleuromamma robusta*	*Metridia gerlachei*	*Metridia lucens*	*Calanus acutus*	*Rhincalanus gigas*	*Oithona frigida*	*Calanus simillimus*	*Drepanopus pectinatus*
oo	151	8	0	0	0	34	1	197	0	9	0	4	12	24	1	975	0	0
30	138	1060	48	10	97	75	6	352	7	10	0	24	17	75	8	2536	2	0
70*	WS 44	1922	88	6	21	58	14	848	0	7	0	0	9	214	3	3084	12	1,571
42	WS 36	594	31	6	25	203	18	169	0	9	0	0	0	505	6	2537	18	3
40	137	1424	120	13	64	106	0	580	2	30	0	59	16	270	10	3085	13	143
14	WS 29	0	0	17	17	5	0	146	0	30	0	29	0	0	18	2031	0	81
18	WS 37	218	51	12	41	42	3	350	2	29	0	0	0	564	21	1253	13	48
48	WS 28	169	0	0	1	1	11	146	0	18	0	0	0	0	4	3064	4	2,563
43	135	10	163	3	16	18	3	117	0	25	0	3	0	24	17	1358	21	2,939
40	131	11	19	17	1	34	4	103	0	7	0	0	6	68	168	1844	32	6
37	WS 39	62	0	12	45	23	5	218	0	17	0	1	1	25	30	1682	25	354
30	WS 50	8	4	6	3	108	9	173	1	12	0	3	1	44	3	1560	66	1,395
24	WS 48	145	0	4	80	10	1	15	6	0	0	0	1	17	1	1095	7	4,318
23	WS 49	18	0	2	30	23	0	61	7	3	1	21	2	27	3	1480	12	3,642
20	124	0	29	11	24	37	1	66	8	13	0	0	5	54	32	1761	6	12
10	WS 51	755	0	7	57	30	0	290	14	22	0	4	7	291	9	2640	2	468
84	WS 52	92	0	3	12	7	5	116	1	3	0	0	0	15	30	1963	2	36
83	WS 40	2857	51	15	491	94	33	1212	3	18	0	6	16	247	52	8391	2	70
80	132	0	58	24	2	55	31	557	0	2	0	0	0	62	70	2045	30	7
80	WS 45	240	0	9	112	144	6	1468	0	4	0	15	71	513	20	3501	3	422
76	134	36	0	5	35	13	0	0	0	0	0	0	0	54	5	556	7	25,234
75	WS 42	35	0	4	90	27	0	287	0	4	0	0	0	94	9	2508	10	2,746
67	128	26	46	4	50	8	5	44	5	4	0	3	13	29	18	718	9	110
57	127	0	55	22	54	7	1	165	10	7	0	1	1	16	18	1520	3	616
40	WS 41	219	0	1	33	17	0	148	7	0	0	0	0	704	1	493	27	8,414
35	WS 33	85	0	2	0	50	1	376	0	0	0	0	0	166	23	2035	17	14,277
22	130	23	0	7	26	16	0	28	10	0	0	0	0	6	23	1491	66	2,369
21	WS 34	110	0	0	2	51	0	201	0	0	0	0	0	67	2	955	66	4,968
00	126	0	102	14	0	24	0	260	4	0	0	6	0	21	26	3764	2	4,557
80	WS 27	19	13	0	37	29	2	177	0	0	0	0	1	1	0	901	1	124
76	WS 31	0	46	2	86	2	9	201	0	0	0	9	1	352	31	2765	87	1,012

* Bottom not reached.

stations, we see in both the shallow- and deep-water series a confirmation of the general principle that the larger numbers of macroplankton organisms and Copepoda of Group *A* are found in the zones of intermediate or higher phosphate values than in the lower phosphate values. The Copepoda in Group *C*, and *Antarctomysis maxima*, again show in general a higher concentration in the regions of lower phosphate values. The factor of depth cannot be the cause for the general sorting out of the vertically migrating plankton either away from or towards the higher concentrations of phytoplankton. It would appear that there must be some automatic mechanism at work, in which the extent of vertical migration is modified according to the density of the phytoplankton in the upper layers. The evidence for such a modification in the vertical migration will be reviewed in the next section.

We have referred to the possibility that one, or perhaps two or three, outstandingly abundant species may be largely controlling the phytoplankton by grazing, and that the remainder of the vertically migrating zooplankton species are being influenced in their distribution by that of the phytoplankton so controlled. It was the publication of Harvey's (1934) paper which led me to this consideration. In the account of the natural history of *Euphausia superba* (pp. 208 *et seq.*) we have collected evidence to show that this species is ecologically probably the most important zooplankton organism in the Antarctic. In our own survey we see that it outnumbers all other species of macro-

Table LXIV

Showing the zooplankton organisms, expressed as numbers per 50 m. haul, taken in the top 250 m. (*or less accordin*
to depth of sounding) *by the N 70 V nets at each night station; the stations being arranged in order o*
decreasing soundings from deep to shallow water

Soundings in metres	Station	Foraminifera	Radiolaria	*Eukrohnia hamata*	*Pelagobia*	Copepoda Group *A*								Copepoda Group *B*			Copepoda Group *C*	
						Calanus propinquus	*Clausocalanus laticeps*	*Ctenocalanus vanus*	*Pareuchaeta antarctica*	*Scolecithricella minor*	*Pleuromamma robusta*	*Metridia gerlachei*	*Metridia lucens*	*Calanus acutus*	*Rhincalanus gigas*	*Oithona frigida*	*Calanus simillimus*	*Drepanopus pectinatus*
3230	139	386	0	1	15	167	18	170	4	17	7	59	12	22	3	1023	9	2
3140*	125	60	16	7	1	36	6	166	13	36	6	20	13	50	26	859	4	2
2582	WS 30	0	0	28	19	14	6	366	0	17	0	21	0	30	67	1339	23	65
2201	WS 61	20	1	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0
2103*	WS 38	436	12	7	76	41	17	352	0	44	6	96	2	116	10	2540	97	0
1752	WS 63	439	75	3	33	66	33	565	0	56	0	8	0	499	9	3055	9	267
1180	WS 26	34	1	19	1	12	3	260	0	57	0	8	10	21	77	1246	6	17
1001	129	186	0	5	30	58	3	299	17	5	0	1	4	13	4	2126	12	51
802	133	963	33	11	4	139	113	144	0	12	0	9	2	405	24	3368	7	3
246	136	271	34	6	27	108	1	359	0	9	0	3	129	19	36	1013	8	11
200	WS 43	520	0	10	108	33	0	193	0	24	3	1	0	82	9	1655	2	309
194	WS 46	23	0	1	30	51	1	70	6	5	0	1	8	176	7	1663	2	263
161	WS 35	630	10	0	154	92	67	446	2	0	0	1	9	539	10	4311	36	1767
160	WS 47	27	0	3	65	33	0	205	0	2	0	2	4	135	14	2038	4	1622

* Bottom not reached.

Table LXV

Correlations of phosphate values and average numbers of macroplankton organisms and Copepoda Groups A and C but divided into shallow- and deep-water stations. For further explanation see text

		Shallow-water stations			Deep-water stations (night stations only)		
Phosphate mg./m.³, average 0–50 m. depth		> 100	90–100	< 90	113–100	99–95	92–86
Number of stations averaged ...		8	10	12	3	3	3
Number of night stations included...		1	3	3	3	3	3
Macroplankton species							
Eukrohnia hamata	N 100 H	5	**51**	28	11	43	**383**
Eukrohnia hamata	N 70 V	9	9	4	7	9	12
Parathemisto gaudichaudi	N 100 H	**90**	48	45	70	**486**	85
Parathemisto gaudichaudi	N 70 H	**53**	22	**118** (26[a])	53	**146**	95
Vibilia antarctica	N 100 H	**5**	1	2	8	**68**	14
Euphausia superba, adult	N 100 H	**804**	197	9	**14,327** (160[b])	**5449**	983
E. frigida, adult	N 100 H	**18**	3	0	105	**162**	**177**
Euphausia spp., adult	N 70 H	**1019**	92	5	220	**746**	458
E. frigida, larvae	N 100 H	2	**170**	11	20	**65**	2
Euphausia spp., larvae	N 70 H	132	**392**	167	456	**940**	306
Thysanoessa spp., adult	N 100 H	23	**105**	37	133	222	**280**
Thysanoessa spp., larvae	N 100 H	0	**158**	13	**56**	1	4
Limacina helicina	N 100 H	31	**569** (89[c])	48	6	**212**	50
Salpa fusiformis	N 100 H	**147**	48	3	610	**5901**	1228
Salpa fusiformis	N 70 H	**69**	12	2	39	**486**	327
Copepoda Group *A*							
Calanus propinquus	N 100 H	194	**992**	260	786	**893**	401
Calanus propinquus	N 70 H	**370**	240	**740** (211[d])	559	**1134**	553
Calanus propinquus	N 70 V	36	38	43	26	**86**	72
Ctenocalanus vanus	N 70 H	2014	**3,083**	2511	4,655	6403	**8221**
Ctenocalanus vanus	N 70 V	273	255	260	275	**344**	234
Clausocalanus laticeps	N 70 H	135	**171**	110	343	**571**	244
Clausocalanus laticeps	N 70 V	7	**11**	2	14	**38**	10
Pareuchaeta antarctica	N 100 H	7	**61**	34	**337**	314	192
Pareuchaeta antarctica	N 70 H	16	**30**	21	**73**	**70**	28
Pareuchaeta antarctica	N 70 V	1	**5**	2	2	5	**6**
Pleuromamma robusta	N 70 H	**31**	0	1	86	**198**	20
Pleuromamma robusta	N 70 V	0	0	0	0	2	**4**
Scolecithricella minor	N 70 H	12	**21**	5	**101**	98	71
Scolecithricella minor	N 70 V	**10**	9	5	**38**	23	23
Metridia gerlachei	N 70 H	**139**	21	26	111	**354**	293
Metridia gerlachei	N 70 V	1	2	4	5	**41**	33
Metridia lucens	N 70 H	148	**180**	26	**459**	122	63
Metridia lucens	N 70 V	**16**	11	7	3	4	8
Copepoda Group *C*							
Calanus simillimus	N 70 H	721	1,128	**1240**	356	1033	**1374**
Calanus simillimus	N 70 V	12	16	**27**	5	**32**	12
Drepanopus pectinatus	N 70 H	1116	14,398	**269, 210** (**82, 192**[e])	274	37	**2241**
Drepanopus pectinatus	N 70 V	962	3,121	**3816**	**95**	49	23
Antarctomysis maxima	N 100 H	1	401	**649**	0	0	0

[a] Excluding one outstanding catch of 1,110.
[b] " " " " 42,500.
[c] " " " " 4,800.
[d] Excluding one outstanding catch of 6,345.
[e] " " " " 2,242,305.

plankton. We know that *Euphausia superba* is largely a phytoplankton feeder. Hart (1934) referring to this species writes:

> The food of these Euphausians consists very largely, if not entirely, of diatoms and other phytoplankton organisms. Thus we have here one of the simplest food chains possible, the building up of the vast body of the whale being only one stage removed from the organic fixation of the radiant energy of the sun by the diatoms....Examination of the stomach contents of adult and post-larval *E. superba* has been made on a number of occasions, though this line of investigation has not been followed up systematically as yet. Small diatoms appear to be ingested by some form of filtering mechanism, and the more typically oceanic species are evidently digested rapidly: recognizable fragments are rather rare even in the crop, the contents of which in krill from waters in which such species are dominant, presenting the appearance of a green porridge. Two forms that occurred constantly and remained clearly recognizable were *Fragilaria antarctica* and *Thalassiosira antarctica*. Torn fragments of the large species *Chaetoceros criophilum* indicated that the adults are capable of triturating and swallowing the larger forms in addition to possessing a filtering mechanism. In post-larval forms entire examples of large Foraminifera (*Globerigina* sp.) were frequently found. Possibly these are eaten for the sake of the contained calcium.

In Fig. 169 are shown the numbers of *Euphausia superba* taken at the shallow-water stations and at the deep-water stations. Each series of stations is arranged in order of decreasing phosphate values, which are also shown as curves. Both day and night stations are included, the latter being indicated by the letter "N". Whilst the number of observations is few, considering the patchiness exhibited by this species, it is perhaps noteworthy that in each series there is a general gradual decline in the number of Euphausians taken as we pass from the higher to the lower phosphate values; we have seen that this reduction in phosphate values indicates an increase in phytoplankton production (cf. Fig. 145). It does seem possible then that this outstanding species *Euphausia superba* may be actually playing an important part in the control of phytoplankton production.

Whilst the data concerning the horizontal and vertical distribution of the plankton, together with the physical and chemical observations, are perhaps fuller than any hitherto examined for an area of the size we are dealing with, it is nevertheless all too scanty. From it we have been attempting to disentangle the two principles, the effect of the zooplankton on the phytoplankton by grazing and the effect of the phytoplankton on the zooplankton by exclusion. Whilst the data are scanty, we are perhaps unusually fortunate in our material. Phytoplankton production is exceptionally heavy in the area. If exclusion is a real effect we have seen that it must be due to a movement of the zooplankton and not simply to mortality, and that such movement must be brought about through vertical migration; in this area extensive vertical migration is a striking feature in the behaviour of the majority of plankton animals. We have in the area too one herbivorous species, *Euphausia superba*, which stands out above all others in ecological importance. From an examination of the data it appears firstly that, whilst all herbivorous animals naturally take their part in reducing the phytoplankton, the phytoplankton itself has a marked influence on the distribution of the vertically migrating zooplankton, and secondly that one or two such outstandingly important herbivorous animals such as *Euphausia superba* may by their grazing have an influence on phytoplankton production overshadowing the influence of all other forms. In areas where there are not one or two quite outstanding herbivorous animals, and where vertical migration may not be so produced, the two principles of grazing and exclusion, which it would appear must be in progress in all areas, may be very much more difficult to disentangle. In our area *Salpa fusiformis* is another very abundant herbivorous animal, which may well play an important part with *Euphausia superba* in controlling phytoplankton production. The two species had a very similar distribution in our survey. If the phytoplankton under particularly favourable conditions of growth should outstep the grazing activities of *Euphausia superba* and *Salpa*, then these vertically migrating animals may be expected to undergo the same gradual process of exclusion, the mechanism of which is discussed in a later section.

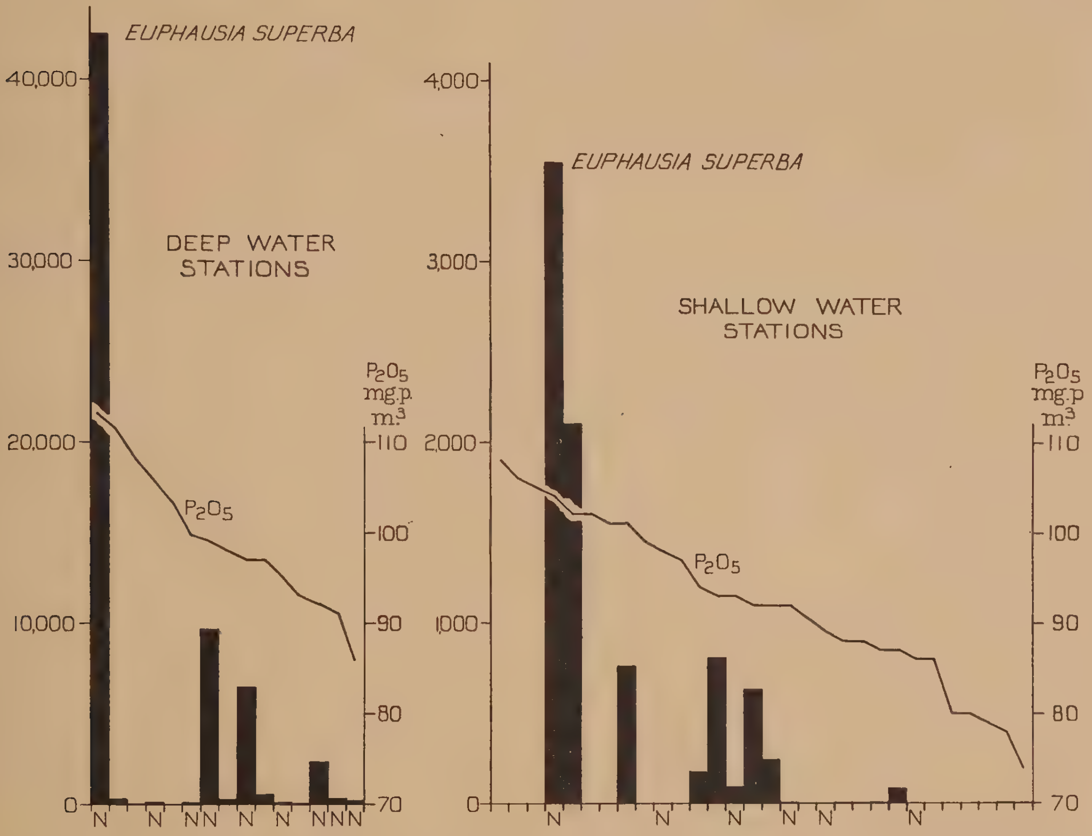

Fig. 169. Showing the numbers of *Euphausia superba* taken in N 100 H nets at deep-water and shallow-water stations, each series being arranged from left to right in order of decreasing phosphate values which are also shown as curves. This figure should be compared with Fig. 145 showing increasing phytoplankton with decreasing phosphate values. The night stations are marked "N".

If a small herbivorous animal becomes exceedingly abundant then it too might play its part in the control of the phytoplankton. On p. 84 it was suggested that the poverty of phytoplankton at Sts. WS 41 and WS 42, accompanied by a reduced phosphate content, which would have led one to expect a rich phytoplankton production, was to be explained by the enormous numbers of the small copepod *Drepanopus pectinatus* bringing about a reduction in the already declining phytoplankton entering the coastal regions. Over two-and-a-quarter million of this copepod were taken in one tow-net haul at St. WS 42. A consideration of water movements showed that this water had flowed from an area where the phytoplankton, made up largely of the small diatom *Chaetoceros socialis*, was exceptionally rich. In this region of dense phytoplankton the small copepods *Drepanopus* were very abundant. It is noteworthy that this instance of a likely reduction of dense phytoplankton by zooplankton should have involved the small copepod, which our later studies have shown to be the one plankton animal in our survey which flourishes in and is not excluded from the highest phytoplankton concentrations met with.

VERTICAL MIGRATION CONSIDERED IN RELATION TO PHYTOPLANKTON

In the preceding section we have seen that, apart from the general effect which a large number of herbivorous animals will have on the phytoplankton population by their grazing (cf. Castracane, 1885, and Harvey, 1934), and particularly such an effect brought about by the outstanding species *Euphausia superba*, there appears to be some principle in operation which modifies the distribution of most of the animals in relation to that of the phytoplankton. There is an accumulation of animals in the zone of intermediate phytoplankton densities, a smaller number of animals in regions of poor phytoplankton, possibly through a shortage of food,[1] but more particularly a smaller number of animals in the regions of dense phytoplankton. It is not a hard and fast reduction; sometimes there may be good catches of a particular animal in rich phytoplankton zones and sometimes poor catches in the intermediate zones; but the effect is seen as an average result in several series of observations selected and treated in different ways. It appears to be a principle applying to planktonic animals belonging to widely different groups, and to be in operation in regions of the survey having different phytoplankton floras. We have further seen that it appears to be closely linked with that common zooplankton phenomenon—vertical migration.

In vertical migration the plankton animals come up into the phytoplankton zone during the night, and sink away from it during the day. We have suggested the hypothesis that the extent or duration of this migration away from the upper layers varies in proportion to the concentrations of the phytoplankton. According to this hypothesis, the exclusion of animals from the dense phytoplankton zones, which we see revealed in horizontal distribution, would be primarily brought about by a diurnal exclusion in the vertical plane. The greater their vertical displacement in distance or the longer in time the further would the animals travel horizontally away from the source of exclusion, if the speed of the ocean currents varies with depth. This mechanism will be fully discussed in a subsequent section. Perhaps a better way of stating the same hypothesis would be to say that the vertically migrating animals, which live for part of the twenty-four hours below the phytoplankton zone, come up into that zone for a period inversely proportional to the density of the phytoplankton.

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[1] This is further discussed on p. 351.

An alternative hypothesis may be introduced under the influence of Harvey's recent work. Considerations in a later section have led to the conception of a simple system of currents, which could act on the vertically migrating animals in such a way that their numbers became reduced in one area and increased in another without there being any actual modification of their migrational range or rhythm.[1] Such a system might explain the similar distribution of a large number of different animals in relation to phytoplankton production, the latter being controlled by the grazing activities of the former. These two hypotheses are not antagonistic. But it is thought that the second method would only be very local and temporary in action, and would hardly account for the correlations of zooplankton with phosphate values, which suggest the gradual adjustment of distribution over a considerable period of time. In the present section we will examine only the first proposition, that of the possible modification of vertical distribution by the phytoplankton, and further consider the general significance of vertical migration in terms of advantage to the organism.

Russell (1928*b*) found in the Plymouth area that during two seasons' observations *Calanus finmarchicus* showed a change in its vertical distribution in the daytime during summer months. From being low in the water in May and June it rose nearer the surface in July, and in August and September, even in bright sunlight, was found close against the surface. He had shown (in 1927*b*) that *Tomopteris helgolandica*, and later that post-larval young of teleostean fish (1930) and *Sagitta* (1933) have a similar change in behaviour. He writes (1933) as follows:

> This appearance of Sagitta in the upper well-illuminated layers in July and August, and perhaps September, is very striking....
>
> That animals belonging to such widely different groups should all show this same type of change in behaviour at this period of the year is very remarkable and it must surely indicate a phenomenon of rather fundamental importance, and may have some significance in the relation of vitamin content.

Bigelow (1924) records *Calanus finmarchicus* swarming at the surface in the daytime on two occasions in July and August in the Gulf of Maine.

Nicholls (1933) in the Clyde area found male, female and stage V *Calanus finmarchicus* more abundant in the upper layers in the daytime on two occasions in 1932 in May and June, and more recently in describing the vertical distribution in 1933 Marshall, Nicholls and Orr (1934) record that males, females and stage V were taken in larger numbers in the top 10 m. in April and May than later in the year.

Russell explains the difference in behaviour of his *Calanus* and *Sagitta* in late summer from that of those in the early summer as being due to different broods reacting differently to light. But now it is seen that the earlier broods of *Calanus* in the Clyde area may behave in the opposite manner to those in the Plymouth area. It appears possible that the relative quantities of phytoplankton might be an explanation in both cases. Normally phytoplankton is richer in May and June than in July, August and September. If vertical migration bears a relation to phytoplankton, this might explain why a number of animals are found higher in the water in the late summer than in early summer. Turning to the Clyde results we see that a similar explanation might hold. In 1932 Nicholls' vertical hauls at his Stations I and II, at which he observed the greater abundance of *Calanus* in the upper layers in May and June, "were divided at the 30 metre line, the object being to simplify counting by confining the diatoms to one part of the catch." He then adds, "As it happened in this year diatoms were seldom rich enough to cause any difficulty of this nature". In 1933 Marshall, Nicholls and Orr divided their hauls at the 10 metre line; they also record the numbers of diatoms in 20 cc. of sea water at the surface and at 30 m. By comparing their Table II and Table IV it is seen that there was a marked falling off in the number of diatoms at the time of the increase in the number of *Calanus* at the surface in April and May.[1]

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[1] Pp. 354–355.

Herdman (1907) in describing his plankton investigations off the Isle of Man to the British Association laid emphasis on the vertical relationship between the zoo- and the phytoplankton, as follows:

> One or two broad features of the collections made were obvious. In the earlier part of the time, up to about the middle of April, diatoms were abundant, and nearly all the gatherings had a greenish tinge. During that period the plants were more abundant in the bottom waters, and the animals at

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[1] I have brought together the two sets of figures from their two tables as follows:

	Calanus above 10 m.			Diatoms at surface per 20 cc.
	V	♀	♂	
Mar. 27	1	—	—	166,000
April 4	18	1	—	111,000
„ 10	15	1	—	15,228
„ 17	63	6	15	5,487
„ 24	85	8	39	7
May 1	140	12	17	26
„ 8	80	21	27	5
„ 15	13	8	5	17
„ 22	4	12	5	85,000
„ 29	11	5	3	65
June 5	—	—	—	19
„ 12	1	—	—	2
„ 19	—	1	—	26
„ 26	1	—	—	104
July 3	1	—	1	2,167
„ 10	—	1	—	19,571
„ 17	—	—	—	107
„ 24	5	—	1	40
„ 31	—	—	—	3,288
Aug. 7	3	—	—	536
„ 14	3	—	—	9,200
„ 21	2	—	—	6,634

the surface. Day after day we found that the two closing vertical nets hauled up from twenty to ten fathoms were of a brownish-green colour, and contained (especially the Nansen) an abundant gathering of diatoms. The surface nets during this time contained more Copepoda. On April 15 and 19, however, when the change in plankton was taking place, the diatoms were found to be mainly on the surface and the Copepoda below. As an example of wide distribution I may cite April 10, when the nets gave consistent results all the afternoon at three localities north of Port Erin, the diatoms being in all cases more abundant at the bottom, and the Copepoda on the surface.

In our present survey we have unfortunately no knowledge of the depth distribution of the phytoplankton, our samples being obtained from a single column of water from 100 m. to the surface. At some stations the phytoplankton may have been near the surface, at others lower down. Nevertheless we must examine our material and see if it offers any direct evidence as to whether or not organisms which undertake vertical migrations are in fact to be found higher in the water in daytime in regions of lower phytoplankton concentration, and deeper in the water in regions of denser phytoplankton. The data are by no means ideal for this purpose. At each station three N 100 H nets were towed horizontally for a mile at the same time, one below the surface, and the other two at depths which, although the length of towing rope was kept constant, varied considerably from station to station due to differences in the speed of the ship under different and difficult weather conditions. Tow-netting in the Antarctic seas, particularly in a square-rigged auxiliary steam vessel, is not so easy as it is in temperate waters. The depths were determined by Kelvin tubes. Some of these stations again were taken in comparatively shallow water, so that the lowest net was not far from the bottom; thus at some stations an organism would be free to migrate to a considerable depth below the lowest net, whilst at other stations this would not be possible.

In considering the position of organisms in the daytime we must be sure that the diurnal vertical migration has ceased or that it has not begun; for this reason we will first of all consider only those stations which lie in times between 0800 and 1600 o'clock. This curtails our number of stations very much, but we shall use all the stations available between these times for which there are phytoplankton records, except those taken outside the Antarctic Zone beyond the line of convergence. There are twenty-two such stations at which N 100 H nets were used, including two taken in March and three in May; eleven have phytoplankton values of less than 0·5 million cells per N 50 V haul (0·003 to 0·187 cells), and eleven have phytoplankton values of over 0·5 million cells (0·55 to 531·2 cells). There are nineteen such stations at which N 70 H nets were used, including three in May; nine have phytoplankton values of less than 0·5 million cells per N 50 V haul (0·006 to 0·358 cells), and ten have phytoplankton values of over 0·5 million cells (0·55 to 531·2 cells). In Table LXVI the numbers of the more important organisms which appear to exhibit animal exclusion are given for these stations in ascending order of phytoplankton values from left to right for surface, middle and lower depths. Numbers over 50 are shown in heavy type, as also are shown the means. The stations taken in March and May are marked by asterisks and dagger marks respectively; the remaining stations are taken in December and January. The stations for March and May are included because, granted that the movement upwards is in response to light, we do not know that it is to intensity of light. Russell's and Nicholls' results quoted above appear to conflict with its being due to intensity, and Clarke (1930) in his laboratory experiments showed that for *Daphnia* it was not actual intensity but changing intensity that produced the upward movement. Nevertheless we see that such indications as there are of some of these organisms being higher in the water in the regions of lower phytoplankton values are largely due to stations taken in March or May, i.e. *Parathemisto*, *Thysanoessa*, and *Ctenocalanus*. These results may be due to the small quantity of phytoplankton at these stations, they may be due to a difference of light intensity, or they may be just due to chance sampling. For *Euphausia superba*, both including and excluding the March and May stations, there is an indication that they may be higher in the water in the lower ranges of phytoplankton values; reading from left to right in order of increasing phytoplankton values, but omitting the March and May stations, we see the daytime depth distribution as follows:

0–5 m.:	0	**160**	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Av. 58 m.:	0	43	**678**	**554**	2	0	2	**264**	3	2	285	.	0	0	0	0	0
Av. 128 m.:	0	140	28	41	1	0	.	52	1	8	**521**	0	0	0	0	**179**	0

Table LXVII shows that these organisms may be as high in the water at night (2000 to 0400 o'clock) in regions of rich phytoplankton as in poor. In Tables LXVIII and LXIX the data for copepods in Group *B* are similarly arranged, and in Tables LXX and LXXI those organisms which appear to "prefer" regions of richer phytoplankton concentrations: *Antarctomysis* and the copepods of Group *C*. These tables are summarized in Table LXXII, which tabulates the mean values for the three different groups under the headings of poorer and richer phytoplankton. The actual individual mean values are of no significance in themselves, but considered together in a group they do seem to indicate as far as our very limited data go a difference in daytime depth distribution within the two ranges of phytoplankton values. If it is legitimate to include the stations in March and May they give an indication that the organisms showing exclusion effects may be higher in the water in daytime in ranges of poor phytoplankton than in rich; and that the animals which are found in larger numbers at stations richer in phytoplankton do not show this but is anything slightly the reverse. Whilst no definite conclusions can be drawn from such limited material, the fact that, in spite of the small number of stations we are dealing with, more evidence in support of a difference in depth in relation to phytoplankton is not found would seem to indicate that if the hypothesis is correct the operation of the principle must depend rather on the length of time the organisms come into the phytoplankton zones than on the depth to which they sink away from it. Another way of presenting the data, which includes the time factor, is shown in Fig. 170. The two diagrams show the positions of stations, marked by crosses, in relation to time of day and phytoplankton values, the latter shown on a logarithmic scale. The time scale ranges from midnight to noon and back to midnight up and down the same scale; thus stations occurring at 0500 and 1900 o'clock would lie opposite the same point on the scale. Against the position of each station in the upper figure are

Table LXVI

Showing the numbers of the more important organisms exhibiting animal exclusion taken at three depths in the series of N 100 H and N 70 H nets at stations in ranges of high and low phytoplankton values during the daylight hours of 0800–1600. *Within each range of phytoplankton values the hauls are arranged in order of stations of ascending phytoplankton values from left to right. Except where indicated by footnote stations are taken in December and January*

Depth of nets in m.	Phytoplankton < 500,000 cells per N 50 V haul		Phytoplankton > 500,000 cells per N 50 V haul	
	Actual numbers in nets at each station	Mean	Actual numbers in nets at each station	Mean
Parathemisto gaudichaudi (N 100 H nets)				
0–5	0*, 0, **69**, 6, 5, **190***, 4†, 0†, 0† ,1, 0	**25**	0, 0, 0, 3, 6, 5, 0, 10, 0, 0, 6	**3**
Av. 59	**347***, 3, 6, 13, 37, **117***, 7†, 2†, 8†, 0, 7	**50**	7, 14, 23, 5, 0, —, 1, 0, 32, 25, 3	**11**
Av. 115	—*, 3, **67**, 20, 48, 33*, 5†, 1†, 0†, 4, 9	**19**	—, 23, 42, 2, 10, 1, 0, 17, 1, 3, 0	**10**
Euphausia superba (N 100 H nets)				
0–5	0*, 0, **160**, 1, 0, **1916***, 0†, 2†, 0†, 0, 0	**189**	0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0	**0**
Av. 59	0*, 0, 43, **678**, **554**, **64***, 0†, 1†, 0†, 2, 0	**122**	2, **264**, 3, 2, **285**, —, 0, 0, 0, 0, 0	**56**
Av. 115	—*, 0, **140**, 28, 41, 0*, 1†, 0†, 0†, 1, 0	**21**	—, **52**, 1, 8, **521**, 0, 0, 0, 0, **179**, 0	**76**
Thysanoessa spp. (N 100 H nets)				
0–5	0*, 0, 0, 0, 0, **880***, 0†, **493†**, 0†, 0, 0	**125**	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0	**0**
Av. 59	**230***, 4, 1, 0, 12, **493***, 17†, 0†, 0†, 0, 1	**69**	1, 37, 0, 0, 16, —, 2, 0, 4, 17, 10	**9**
Av. 115	—*, 17, 13, 9, 5, **200***, **256†**, 3†, **54†**, 6, 2	**57**	—, **57**, **571**, 8, 20, 8, 16, 1, 0, 15, **94**	**79**
Limacina helicina (N 100 H nets)				
0–5	0*, 12, 1, 28, 1, 0*, 0†, 0†, 0†, 0, 0	**4**	0, 0, 0, 0, 46, 3, 3, 0, 25, 0, 1	**7**
Av. 59	0*, 2, 3, 4, **496**, 0*, 0†, 0†, 0†, 8, 2	**47**	0, 0, 0, 0, 9, —, 0, 0, **101**, **128**, 1	**24**
Av. 115	—*, 2, 31, 1, 0, 0*, 0†, 0†, 0†, 3, 1	**4**	—, 0, 0, 0, **344**, 1, 2, 0, 3, 13, 1	**36**
Salpa fusiformis (N 100 H nets)				
0–5	0*, 0, 0, 2, 0, 0*, 4†, 0†, 0†, 0, 0	**1**	0, 0, 0, 1, 0, 0, 0, 2, 1, 0, 0	**0**
Av. 59	0*, 0, 2, 1, **104**, 0*, 0†, 0†, 0†, 0, 0	**10**	0, 2, 0, 0, 0, —, 0, 0, **130**, **163**, 0	**30**
Av. 115	—*, 0, 0, 10, **104**, 0*, 0†, 0†, 0†, 0, 0	**11**	—, **247**, 0, 3, 2, 0, 0, **714**, 0, 39, 0	**101**
Calanus propinquus (N 70 H nets)				
0–5	1, 0, 0, 0†, 2†, 0†, 0, 8, 18	**3**	7, 12, 0, 0, 0, 1, 0, 0, 0, 0	**2**
Av. 61	4, **428**, 6, 0†, 6†, 4†, 23, 9, —	**60**	34, 7, 0, 0, **88**, 1, 46, 0, **100**, 20	**30**
Av. 115	**84**, **896**, **352**, 26†, 22†, 2†, **520**, **158**, 32	**232**	—, **911**, 4, 0, **140**, 33, 14, —, **260**, **280**	**205**
Clausocalanus laticeps (N 70 H nets)				
0–5	0, 0, 0, 6†, 4†, 1†, 0, 0, 0	**1**	0, 8, 0, 0, 1, 0, 0, 0, 0, 4	**1**
Av. 61	0, **720**, 5, 10†, 0†, 0†, 0, 0, —	**92**	12, 4, 0, 0, 36, 0, 0, 4, 0, 40	**10**
Av. 115	4, 44, **280**, 8†, 17†, 6†, 40, 4, 0	**45**	—, **185**, 12, **60**, **100**, 9, 6, —, **130**, **80**	**73**
Ctenocalanus vanus (N 70 H nets)				
0–5	4, 0, 0, **560†**, **250†**, **101†**, 0, 0, 4	**102**	0, **160**, 0, 0, 48, 0, 0, 0, 0, 12	**22**
Av. 61	5, **960**, **64**, **126†**, 0†, **400†**, **70**, 21, —	**206**	**256**, **52**, 0, 0, **144**, 20, **160**, 0, **1200**, **1600**	**343**
Av. 115	**60**, **2176**, **2112**, **716†**, **256†**, 0†, **200**, **192**, **2112**	**869**	—, **2300**, 8, **380**, **2740**, 33, 48, —, **4135**, **200**	**1231**

— = No sample. * = Station taken in March. † = Station taken in May.

Table LXVII

Showing the numbers of the more important organisms exhibiting animal exclusion taken at three depths in the series of N 100 H and N 70 H nets at stations in ranges of high and low phytoplankton values during the hours of darkness 2000–0400. *Within each range of phytoplankton values the hauls are arranged in order of stations of ascending phytoplankton values from left to right. Except where indicated by footnote stations are taken in December and January*

Depth of nets in m.	Phytoplankton < 500,000 cells per N 50 V haul		Phytoplankton > 500,000 cells per N 50 V haul	
	Actual numbers in nets at each station	Mean	Actual numbers in nets at each station	Mean
Parathemisto gaudichaudi (N 100 H nets)				
0–5	**54**, 36, **457**, **1128**, **135**, 8	**303**	4, **124**, **192**, **136**, 2, **106**, 16, **58**	**80**
Av. 58	0, 5, 28, 8, 0, 3	**7**	20, 0, 0, 14, 0, 2, 3, 4	**5**
Av. 128	0, **64**, 41, 21, **60**, 1	**31**	0, 0, 4, 20, 0, —, 3, **60**	**12**
Euphausia superba (N 100 H nets)				
0–5	0, 4, **755**, **9600**, **386**, **56**	**1800**	6, **908**, **368**, 0, **212**, 0, 16, 0	**189**
Av. 58	2, 4, **2152**, **53**, **2263**, **51**	**754**	0, **1456**, 0, 0, 0, 0, 30, 0	**186**
Av. 128	4, **164**, **882**, 0, **3900**, 1	**825**	0, 1, 4, 0, 0, —, **53**, 0	**8**
Thysanoessa spp. (N 100 H nets)				
0–5	4, 0, 23, 0, 0, 0	**5**	6, 12, 0, 22, 0, 0, 0, 2	**5**
Av. 58	1, 0, 32, 13, 16, 11	**12**	**556**, 0, 32, 0, **68**, 3, **208**, **152**	**127**
Av. 128	0, 56, 19, **116**, **492**, **104**	**131**	4, 39, 44, 8, **700**, —, 19, 12	**118**
Limacina helicina (N 100 H nets)				
0–5	**82**, 0, 0, **60**, **242**, 0	**64**	16, **108**, 0, 15, 0, 3, **4768**, **284**	**649**
Av. 58	0, **94**, 0, **50**, 0, 1	**24**	6, 0, 0, **79**, 0, 13, 11, 12	**15**
Av. 128	0, **96**, 24, 47, 48, 11	**38**	0, 0, 0, **88**, 4, —, 21, 0	**16**
Salpa fusiformis (N 100 H nets)				
0–5	5, **10,730**, **163**, **276**, **365**, **96**	**1939**	36, **1552**, **444**, 5, **386**, 0, 7, 2	**304**
Av. 58	0, **105**, **192**, **104**, **272**, **460**	**189**	18, 40, **356**, 14, **892**, 4, 2, 0	**166**
Av. 128	0, 0, **103**, **560**, **5292**, **56**	**1002**	0, 0, **368**, **164**, **236**, —, 0, 0	**110**
Calanus propinquus (N 70 H nets)				
0–5	**5600**, 0†, 0, **800**, **830**, 16, **140**	**1055**	**252**, 40, **1120**, 36, **800**, **420**, **133**, 20	**353**
Av. 64	**615**, 32†, 0, **112**, 13, **1200**, 24	**285**	**184**, **96**, 4, **220**, 1, 32, 10, **60**	**76**
Av. 111	**130**, **140**†, **66**, **790**, 19, **200**, 0	**192**	40, **400**, **82**, **160**, **61**, —, 20, **320**	**155**
Clausocalanus laticeps (N 70 H nets)				
0–5	0, 0†, 8, **320**, **545**, **304**, 36	**202**	**120**, 0, **920**, 4, **120**, 0, **420**, 0	**198**
Av. 64	10, **56**†, 4, **196**, 18, **120**, 10	**59**	16, 20, 2, **440**, 21, 8, 10, **85**	**75**
Av. 111	5, **60**†, **102**, **105**, 5; **150**, 0	**61**	**80**, **80**, 26, **130**, 0, —, **80**, 20	**59**
Ctenocalanus vanus (N 70 H nets)				
0–5	0, 0†, 0, 0, **640**, 0, **1220**	**266**	**816**, 0, **6800**, **208**, **160**, 0, **6260**, 0	**1781**
Av. 64	**1120**, **80**†, 12, **52**, 0, **4080**, 40	**769**	**2848**, 24, 12, **960**, 0, **256**, **520**, **1060**	**710**
Av. 111	**560**, **3000**†, **1872**, **10,560**, 15, **8070**, 0	**3440**	**1240**, **8960**, **1360**, **3920**, **14,940**, —, **3600**, **1736**	**5108**

— = No sample. † = Station taken in May.

Table LXVIII

Showing the numbers of Calanus acutus, Rhincalanus gigas, *and* Oithona frigida *taken at three depths at stations in ranges of high and low phytoplankton values* during the daylight hours of 0800–1600. *Within each range of phytoplankton values the hauls are arranged in order of stations of ascending phytoplankton values from left to right. Except where indicated by footnote stations are taken in December and January*

Depth of nets in m.	Phytoplankton < 500,000 cells per N 50 V haul		Phytoplankton > 500,000 cells per N 50 V haul	
	Actual numbers in nets at each station	Mean	Actual numbers in nets at each station	Mean
Calanus acutus (N 70 H nets)				
0–5	0, 0, 0, 0†, 0†, 1†, 0, 0, 0	**0**	2, **198**, 0, 0, 0, 0, 0, 0, 0, 2	**20**
Av. 61	0, **4380**, 2, 1†, 0†, 6†, 1, 3, —	**549**	12, 39, 0, 40, **50**, 4, **52**, **192**, **800**, **720**	**191**
Av. 115	**72**, **640**, **208**, 6†, 16†, 20†, 40, **164**, 16	**131**	—, **5600**, 1, 40, **100**, 39, 6, —, **1275**, **120**	898
Rhincalanus gigas (N 70 H nets)				
0–5	0, 0, 0, 1†, 2†, 1†, 0, 0, 0	**0**	0, 0, 0, 0, 0, 0, 1, 0, 0, 0	**0**
Av. 61	0, 4, 0, 2†, 5†, 0†, 0, 0 —,	**1**	**141**, 15, 0, 20, 6, 3, 14, 16, **380**, **120**	72
Av. 115	12, **188**, **220**, **62**†, **88**†, 27†, 41, 13, **388**	**115**	—, 37, 0, **80**, **180**, **318**, **50**, —, **200**, **52**	**115**
Oithona frigida (expressed in thousands) (N 70 H nets)				
0–5	0, 0, 0, 17†, 12†, 30†, 0, 0, 0	**7**	0, 15, 0, 0, 1, 1, 0, 0, 0, 1	**2**
Av. 61	4, **1418**, 0, 2†, 3†, **52**†, 2, 0, —	**185**	19, 2, 1, **82**, 11, 1, 38, 22, 4	**20**
Av. 115	0, 13, 42, 15†, 11†, 21†, 27, 0, 31	**18**	—, **139**, 0, **59**, 10, 7, 7, —, 30, 3	**32**

— = No Sample. † = Station taken in May.

Table LXIX

Same as Table LXVIII but for stations during hours of darkness 2000–0400

Depth of nets in m.	Phytoplankton < 500,000 cells per N 50 V haul		Phytoplankton > 500,000 cells per N 50 V haul	
	Actual numbers in nets at each station	Mean	Actual numbers in nets at each station	Mean
Calanus acutus (N 70 H nets)				
0–5	**160**, 0†, 0, 0, **180**, 0, 0	**49**	**116**, 2, 40, **400**, **260**, **2840**, **980**, **52**	586
Av. 64	**1345**, 8†, 0, 20, 4, **520**, 8	**272**	24, 0, 20, **1760**, 0, **896**, **120**, **330**	394
Av. 111	**630**, 20†, **300**, **3310**, 1, **320**, 0	**654**	**500**, 40, **1052**, **2680**, **1380**, —, **280**, **2496**	**1204**
Rhincalanus gigas (N 70 H nets)				
0–5	0, 0†, 0, 0, 2, 0, 0	**0**	3, 0, 0, 0, 0, 0, 7, 0	**1**
Av. 64	5, 0†, 0, 0, 0, 0, 0	**1**	**60**, 0, 1, **100**, 0, 16, 8, 5	**24**
Av. 111	15, 0†, 15, **70**, 0, 0, 0	**14**	40, **400**, 8, **110**, **780**, —, 20, 16	**196**
Oithona frigida (expressed in thousands) (N 70 H nets)				
0–5	0, 0†, 0, 0, 25, 0, 0	**4**	31, 0, 4, 10, 0, 24, **64**, 0	**16**
Av. 64	**69**, 1†, 0, 48, 0, 14, 5	**20**	34, 0, 0, 46, 0, 5, 7, 11	**13**
Av. 111	10, 23†, 49, **78**, 0, **120**, 0	**40**	8, 38, 10, **65**, **62**, —, **285**, 77	78

— = No sample. † = Station taken in May.

Table LXX

Showing the numbers of Antarctomysis maxima, Calanus simillimus, *and* Drepanopus pectinatus *taken at three depths at stations in ranges of high and low phytoplankton values* during the daylight hours of 0800–1600. *Within each range of phytoplankton values the hauls are arranged in order of stations of ascending phytoplankton values from left to right. Except where indicated by footnote stations are taken in December and January*

Depth of nets in m.	Phytoplankton < 500,000 cells per N 50 V haul		Phytoplankton > 500,000 cells per N 50 V haul	
	Actual numbers in nets at each station	Mean	Actual numbers in nets at each station	Mean
	Antarctomysis maxima (N 100 H nets)			
0–5	0*, 0, 0, 0, 0, 0*, 0†, 0†, 0†, 0, 0	**0**	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2	**0**
Av. 59	0*, 0, 0, 0, 0, 0*, 0†, 0†, 0†, 0, 0	**0**	5, 0, 0, 0, 0, —, 11, 0, **114**, 0, **69**	**20**
Av. 115	—, **101**, 1, 0, 0, 0*, 0†, 0†, 0†, 0, 0	**10**	—, 0, 0, 0, 0, 1, 0, 0, 0, 0, **221**	**22**
	Calanus simillimus (N 70 H nets)			
0–5	4, 0, 0, 3†, 18†, 0†, 0, 0, 2	**3**	0, **68**, 0, 0, 4, 0, 0, 0, 0, 6	**8**
Av. 61	3, **100**, 4, 7†, **101†**, 3†, 5, 24, —	**31**	**100**, **59**, 0, **1060**, **362**, 0, 28, 12, 20, 40	**168**
Av. 115	**540**, 16, **1104**, 30†, 23†, 1†, **260**, **107**, 40	**236**	—, **160**, 0, **400**, **220**, **60**, 30, —, 25, 40	**117**
	Drepanopus pectinatus (N 70 H nets)			
0–5	3, 0, 1, 0†, 0†, 0†, 0, 9, 39	**6**	10, **268**, 0, 0, 0, 4, 2, 0, 0, **2374**	**266**
Av. 61	**248**, 0, **52**, 0†, 0†, 0†, **280**, **1256**, —	**230**	0, **332**, 40, 0, 0, 0, 8, 0, 0, **60**	**44**
Av. 115	**11,520**, 0, 24, 1†, 0†, 0†, **4960**, **732**, **3456**	**2299**	—, **200**, 0, 0, 0, 18, **216**, —, **115**, **43,560**	**5514**

— = No sample. * = Station taken in March. † = Station taken in May.

Table LXXI

Same as Table LXX but for stations during hours of darkness 2000–0400

Depth of nets in m.	Phytoplankton < 500,000 cells per N 50 V haul		Phytoplankton > 500,000 cells per N 50 V haul	
	Actual numbers in nets at each station	Mean	Actual numbers in nets at each station	Mean
	Antarctomysis maxima (N 100 H nets)			
0–5	0, 0, 0, 0, 0, 0	**0**	0, 0, 0, 0, 0, 0, 32, 34	**8**
Av. 58	2, 0, 0, 0, 0, 0	**0**	**390**, 0, 0, 1, 0, 16, **877**, **1624**	**364**
Av. 128	12, 0, 0, 0, 0, 0	**2**	12, 0, 0, 0, 0, —, **172**, **1128**	**187**
	Calanus simillimus (N 70 H nets)			
0–5	0, **6400†**, 0, 24, **2773**, **845**, **588**, 6	**1,329**	**56**, 12, **480**, **200**, **3220**, **900**, **259**, **880**	**751**
Av. 64	**85**, 8†, 8, **248**, 14, **360**, 1	**103**	**1276**, **145**, 0, **320**, 38, 12, 10, **175**	**247**
Av. 111	30, **60†**, **180**, 25, 4, **255**, 0	**79**	20, **160**, 14, **255**, **218**, —, 20, **56**	**106**
	Drepanopus pectinatus (N 70 H nets)			
0–5	**2,240,000**, 0†, **1200**, 0, 45, 7, 0	**320,179**	**5768**, **176**, 0, **1608**, **6480**, **46,080**, **385**, **511,680**	**71,522**
Av. 64	**495**, 0†, 6, 48, 22, 0, 0	**82**	**192**, 12, 0, **1000**, 0, **48,192**, 20, **44,940**	**11,794**
Av. 111	**1810**, 0†, 0, 0, 0, 0, 0	**259**	**120**, 24, **64**, **1730**, 0, —, 20, **47,264**	**7,032**

— = No sample. † = Station taken in May.

Table LXXII

Summarizing Tables LXVI to LXXI, and showing the average numbers of the different animals taken in three ranges of depth at stations in relation to low and high ranges of phytoplankton and daylight and darkness

Types of animals	The more important organisms showing animal exclusion																Copepoda Group *B*						Animals "preferring" a higher range of phytoplankton					
Phytoplankton ranges ...	Poorer phytoplankton								Richer phytoplankton								Poorer phytoplankton			Richer phytoplankton			Poorer phytoplankton			Richer phytoplankton		
Species	*Parathemisto gaudichaudi*	*Euphausia superba*	*Thysanoessa* spp.	*Limacina helicina*	*Salpa fusiformis*	*Calanus propinquus*	*Clausocalanus laticeps*	*Ctenocalanus vanus*	*Parathemisto gaudichaudi*	*Euphausia superba*	*Thysanoessa* spp.	*Limacina helicina*	*Salpa fusiformis*	*Calanus propinquus*	*Clausocalanus laticeps*	*Ctenocalanus vanus*	*Calanus acutus*	*Rhincalanus gigas*	*Oithona frigida*	*Calanus acutus*	*Rhincalanus gigas*	*Oithona frigida*	*Antarctomysis maxima*	*Calanus simillimus*	*Drepanopus pectinatus*	*Antarctomysis maxima*	*Calanus simillimus*	*Drepanopus pectinatus*
Daylight stations (0800–1600 hours)																			*			*						
Surface nets	25	**189**	**125**	4	1	3	1	102	3	0	0	7	0	2	1	22	0	0	7	20	0	2	0	3	6	0	8	266
Middle nets	**50**	122	69	**47**	10	60	**92**	206	11	56	9	24	30	30	10	343	**549**	1	**185**	191	72	20	0	31	230	20	**168**	44
Lower nets	19	21	57	4	11	**232**	45	**869**	10	**76**	**79**	**36**	**101**	**205**	**73**	**1231**	131	**115**	18	**898**	**115**	**32**	**10**	**236**	**2,299**	**22**	117	**5,514**
Night stations (2000–0400 hours)																												
Surface nets	**303**	**1800**	5	**64**	**1939**	**1055**	**202**	266	**80**	**189**	5	**649**	**304**	**353**	**189**	1781	49	0	4	586	1	16	0	**1329**	**320,179**	8	**751**	**71,522**
Middle nets	7	754	12	24	189	285	59	769	5	**186**	**127**	15	166	76	75	710	272	1	20	394	24	13	0	103	82	**364**	247	11,794
Lower nets	31	825	**131**	38	1002	192	61	**3440**	12	8	118	16	110	155	59	**5108**	**654**	**14**	**40**	**1204**	**196**	**78**	2	79	259	187	106	7,032

* Expressed in thousands.

shown the various catches of macroplankton organisms, which appear to exhibit exclusion (i.e. all those except *Antarctomysis*), together with *Calanus propinquus*, *Clausocalanus* and *Ctenocalanus*, taken in the surface nets both N 100 H and N 70 H; for each organism catches of over 100 are shown as circles and those of over 50 as squares. The lower figure shows similar catches but in the lower of the three nets. We see an indication that the poorer the phytoplankton the longer in time from midnight may organisms be found in numbers at the surface. In the area of the figure bounded by the line *ABC* there are eighteen stations, at nine of which organisms are found in numbers of over 50 or 100 at the surface; in the area *ABD* there are twelve stations, at none of which are such numbers of organisms found. Yet the lower figure shows that such organisms are present at these stations, though lower in the water.

Our material was not collected with a view to showing the depth relationship of zooplankton to phytoplankton; it is clear that to obtain definite evidence on this point a series of special hauls should be taken at different times of the day and night at a number of stations in different concentrations of phytoplankton, and that the details of the vertical distribution of the phytoplankton should also be studied.

Whilst this explanation must remain for the present a hypothesis, it may be well, as a possible guide for future experiment and observation, to consider various factors which might bring about such a modification in vertical migration in relation to the phytoplankton.

It is clear that the simple physical presence of a large number of plant cells in the water could not in itself be the cause of such a modification. Whilst it is theoretically possible to imagine plant cells so numerous in the water as to interfere with the locomotion or other activities of the plankton animals, we do in fact observe the animals coming up into the denser phytoplankton zones during the night but avoiding them during the day.

The actual reduction in phosphates cannot be the cause. We see different ranges of phosphate values in different areas at different seasons; the zooplankton is only correlated with a relative reduction of phosphates and only so long as it is corresponding with phytoplankton production. In the English Channel, where the phosphate content is reduced to negligible quantities during the summer, the animal plankton flourishes, and, as Russell has shown, may even come to the surface in the daytime.

In 1912 a number of the plaice in a pond at the fish hatchery at Port Erin died from a severe epidemic which produced an ulceration of the skin. Moore, Prideaux and Herdman (1915) examined the water chemically; they found it was highly alkaline and that the water was green from the presence of "floating monocellular algae and a minute green flagellate Infusorian in great profusion". They came to the conclusion that "photosynthesis by green algae causes a marked diminution in hydrogen-ion concentration in sea water, and in confined volumes of water this variation in the direction of increased alkalinity may act as the inducing or favouring cause for pathological conditions and disease". This led them to make a study of the seasonal variations in the hydrogen-ion concentration (*p*H) in the sea, and they found that there was a distinct increase in

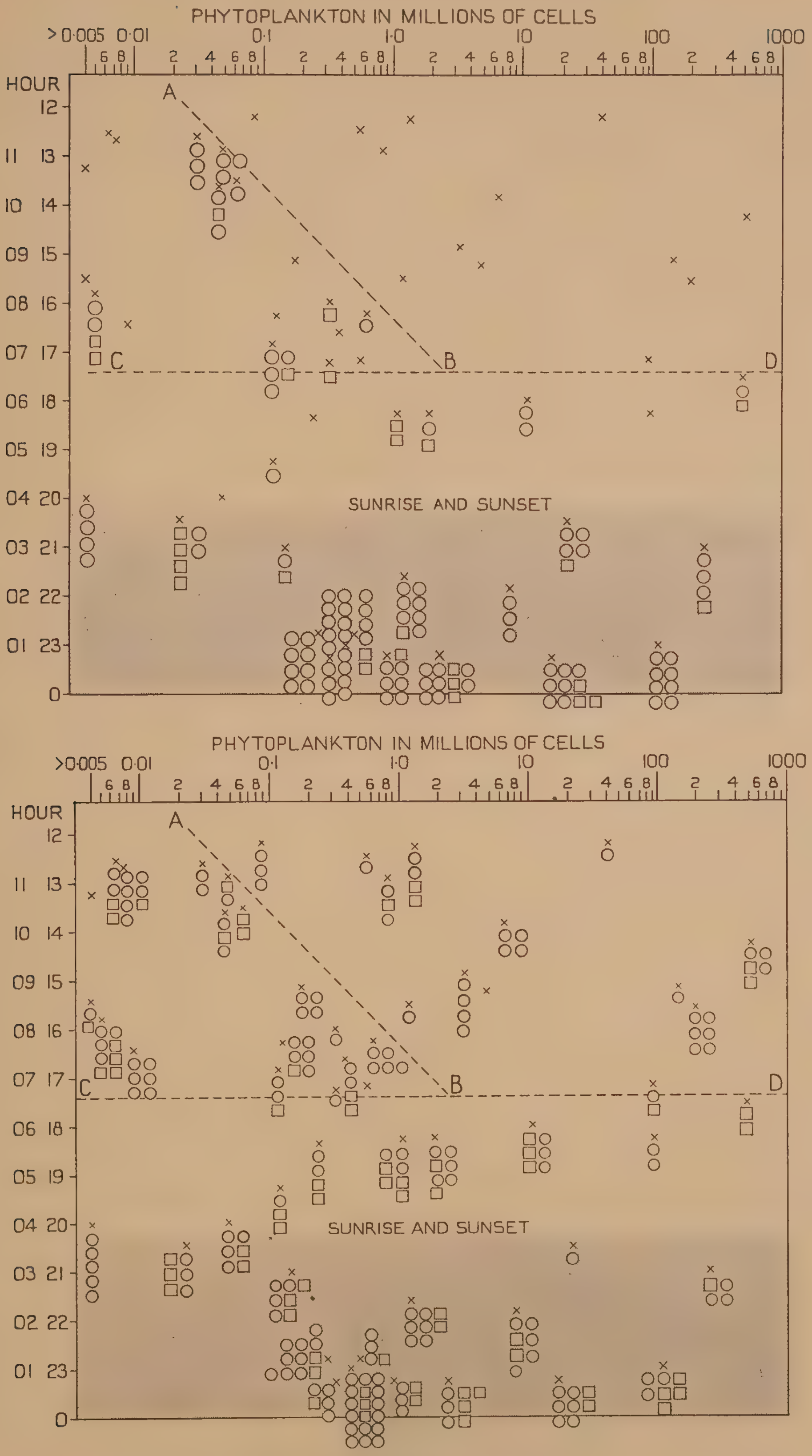

Fig. 170. For explanation see text.

alkalinity in spring, and that this increase was due to the photosynthetic activity of the phytoplankton.

Atkins (1923*b*) has made further studies of the seasonal changes in alkalinity, and has come to the conclusion that "in a general way the *p*H maxima (alkalinity maxima) may be correlated with the diatom maxima in the early summer and autumn, but no quantitative results have as yet been obtained on this point. The alteration in the reaction of the water may be used to make an approximate estimation of the total crop of algal plankton".

Many years ago Loeb (1906) showed that Copepoda became positively phototropic by reducing the alkalinity of the environment. More recently Fox (1925) has shown that both changes in light and *p*H can independently bring about the vertical migration of *Paramecium*.

It is well known that very small changes in hydrogen-ion concentrations have a marked effect upon the animal organism. Professor Lloyd Hopwood, in his article on "Physics in Medicine" in the recent edition of the *Encyclopædia Britannica*, writes as follows:

> An alteration in acidity is the causative factor in the regulation of respiration, the activity of muscle, and the excitability of nerve, and plays an important part in regulating excretion and secretion.
>
> The powerful effects of variation in hydrogen-ion concentrations on physiological processes require the existence of mechanisms for the prevention of considerable changes of this kind. One of the main functions of the blood is to provide this. It can itself withstand the addition of relatively considerable amounts of free acid or free alkali without much change in its reaction, largely owing to the presence of carbonates and phosphates. The electrolytic dissociation theory provides the only satisfactory explanation of this.

He is of course referring to the terrestrial vertebrate. The planktonic organism is bathed in a great medium—the sea—and even if we imagine it possible for the organism to regulate to some extent the alkalinity of this medium in its immediate vicinity, we cannot imagine that it could counteract the larger variations that may at times occur and be harmful to it. We might expect that it would if possible move within the medium to a region more congenial to it.

Shelford and Powers in 1915[1] showed how sensitive fish may be to small changes in *p*H, and Powers (1921, 1922) traced the limits of *p*H within which various fish were found in Puget Sound. He only once found herring in water with a *p*H above 7·9 and never found them in water below *p*H 7·71. Atkins (1923*b*) however writes:

> ...While such preferences and variations may be observed in estuarine waters, in the sea around this coast, the water is, as demonstrated by the figures already given, very uniform in alkalinity, and during winter not far from *p*H 8·14, yet herring are at times caught in great quantity, as well as other fish. One can only conclude that under such conditions the hydrogen ion concentration of the water can be of no importance in determining the movements of fish....

Saunders (1924) has described the swarming of the protozoan *Spirostomum* induced by increased alkalinity due to the photosynthesis of algae. We have ourselves described on p. 210 the swarming of immature *Euphausia superba*, a close swarming apparently independent of the larger patchy distribution also recorded. Atkins (1922) writes concerning the herring and *p*H values that:

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[1] Quoted by Atkins (1923*b*).

> ...It must not, however, be left out of consideration that large numbers of fish themselves modify the hydrogen-ion concentration by their respiration, and the water in a shoal must be less alkaline than the sea water in general. These shoal fish are presumably accustomed to this somewhat stuffy sea-atmosphere, and so it appears probable that if separated from the shoal a herring by making for a region of lower *p*H would be led back to the shoal....

It seems possible that the laying down of skeletal structures of silicate or carbonate would also be a counteraction to the increased alkalinity set up by photosynthesis in the upper layers.

Unfortunately in our present survey *p*H observations were taken at only a limited number of stations. They were taken only by the 'Discovery', and since she did not work the stations to the west and south of the island we have no *p*H observations in these regions where the phytoplankton production was greatest. The differences in *p*H values in this survey were not large; they are tabulated in Table LXXIII arranged in order of stations[1] of ascending phytoplankton values. The higher phytoplankton values and the *p*H values of 8·34[2] and over are shown in heavy type. Whilst the differences in *p*H values are slight, we see that the higher *p*H values are in general correlated with the higher phytoplankton values. It must be remembered that measurements of phytoplankton values by numbers of cells (and also by volume) have been shown to give only a rough estimation (p. 68). It should be noted too that the stations are taken at different times of the day and under different weather conditions, so that the rate of photosynthesis may vary considerably at different stations. The states of weather are tabulated in Beaufort notations. The high *p*H values, 8·33, at the two stations of lowest phytoplankton values may in part be due to the fact that the stations were worked on sunny days (shown as b.c. and b. in the table) when the photosynthetic activity would be higher than on cloudy days. Dividing the series of *p*H values into four groups of four stations each we see that the average *p*H values for the groups are 8·29, 8·32, 8·31 and 8·34. Now very much higher phytoplankton catches were taken at stations at which no *p*H determinations were made. It seems reasonable to suppose that there would be higher *p*H values on the average at these stations than at those given in the table. We have already seen in the later surveys that the *p*H values in general had a correlation with the reduced phosphate values and so with phytoplankton production. But in these surveys the ranges in *p*H values are not great; they are tabulated on p. 336.

We see that not only are the ranges met with small, but that if increased alkalinity is indeed an effective cause in modifying vertical migration then it would not be a particular degree of alkalinity that brought it about, but a certain increase relative to the lower values within the area at the time. The highest *p*H value in the South Shetlands survey of 1929 is equal to the lowest *p*H value in the South Georgia survey of 1928–9. It is not an impossible conception that the animal organisms may be adjusted at different times to work in media of different alkalinity, and that increases a little beyond the range to which they were at the time adjusted might be effective in bringing about a change in behaviour.

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[1] St. 139, where no phytoplankton observations were taken, is omitted.

[2] Unless otherwise stated the *p*H values quoted in this section represent the average *p*H values for the top 50 m. of water based on samples taken at 0, 10, 20, 30, 40 and 50 m. It should also be noted that the *p*H values used in this report differ from those given in the published Station Lists in that they have been corrected for temperature, salt error and the effect of pressure. I am much indebted to Mr G. E. R. Deacon for kindly estimating the corrections for me.

Season	Month	Mean *p*H values of top 50 m.			
		Minimum	Mean of 5 lowest values	Mean of 5 highest values	Maximum
South Georgia 1928–9	Dec.–Jan.	8·14	8·17	8·31	8·36
South Shetlands 1929	Feb.	8·00	8·04	8·13	8·14
South Georgia 1930	Jan.*	8·16	8·18	8·28	8·29
1930	Nov.	8·13	8·13	8·26	8·33

* The data for February have been omitted because of the evidence, already given on p. 288, that the phytoplankton in this month had died down.

Table LXXIII

Stations at which pH *determinations were made arranged in order of ascending phytoplankton values, expressed as millions of cells per N 50 V haul, together with average* pH *values for top 50 m. State of weather and time of day also given*

Phytoplankton in millions of cells	Station No.	Average *p*H 0–50 m.	Average *p*H of stations in groups of four	Weather (Beaufort notations*)	Hour
0·005	134	8·33	8·29	b.c.	1440
0·006	130	8·33		b.	1030
0·007	138	8·31		c.	0800
0·084	126	8·17		o.s.	1055
0·112	135	8·29	8·32	o.m.	1805
0·187	127	8·31		c.	1345
0·241	128	8·32		o.v.	1710
0·276	136	**8·34**		o.f.	2138
0·323	133	8·22	8·31	o.	2012
0·430	129	**8·35**		o.v.	2015
0·800	151	**8·35**		b.c.	0915
1·116	132	8·32		o.	1700
1·317	125	**8·35**	8·34	o.	2300
1·800	137	**8·34**		o.f.	0307
3·328	131	8·32		b.c.	1325
11·06	124	**8·34**		o.s.	1600

* Beaufort weather notations:

b. = blue sky.	f. = fog.
b.c. = blue sky and some cloud.	m. = mist.
c. = cloudy sky.	s. = snow.
o. = overcast.	v. = unusually good visibility.

We have suggested that the cause might be one which varies during the twenty-four hours, bringing about a deeper vertical migration of the zooplankton organisms during the day in regions of denser phytoplankton, but allowing the organisms to return to the upper layers during the night. Legendre (1922) has studied the changes in *p*H values throughout the day in the coastal waters of France, showing that they may be considerable, and linking them with the photosynthetic activity of the littoral algae. At 0800 he found a *p*H value of 7·99, at 1500 one of 8·19 and at 1900 one of 8·01. He comments upon the fact that such diurnal changes in the open ocean due to the photosynthetic activities of the phytoplankton have not been found to be anything like so great. We have at present only two records of the changes in *p*H during the day at fixed points within our area, that at St. 41 when observations were taken at 1300, 1715 and 2105, and at St. 393 in a later survey when observations were taken at 1320, 1847, 2248 and 0255. The data from these two stations are given in Tables LXXIV and LXXV. The changes recorded are very slight indeed.

In Table LXXVI we show the range of *p*H values down to 200 m. at the stations in our survey for which such data are available. The stations are arranged in order of phytoplankton values. The *p*H values of 8·30 and over are printed in heavy type, those below 8·10 are printed in italics. The night stations—those taken between sunset and sunrise—are shown at the foot of the table by the letter N. The higher alkalinity of the upper photosynthetic layers is clearly seen; but whilst there is in general a slight tendency for the higher *p*H values to extend lower in the water in regions of high phytoplankton, it is not sufficiently pronounced to offer a reasonable explanation for the zooplankton remaining high in the water in the regions of lower phytoplankton. At St. 134, which is one of very low phytoplankton and at which *Euphausia superba* and *Parathemisto* were taken at the surface in numbers, the upper *p*H values are the same as those at St. 124, the highest phytoplankton station for which we have *p*H data.

Table LXXIV

Repeated pH *observations at St.* 41

Hour...	1300	1715	2105
Depth in m.			
0	*8·30*	*8·30*	8·24
5	*8·30*	8·29	8·28
10	8·29	8·29	8·29
20	8·29	8·29	8·29
30	8·29	8·29	8·29
40	8·29	8·29	8·29
50	8·29	8·29	8·29
75	8·28	8·28	8·28
100	8·20	8·20	**8·15**
150	**8·15**	**8·14**	**8·01**
200	**7·98**	**7·98**	**7·98**
250	**7·95**	**7·95**	**7·96**

Table LXXV

Repeated pH *observations at St.* 393

Hour...	1320	1847	2248	0255
Depth in m.				
0	*8·20*	*8·20*	8·19	8·19
10	*8·20*	8·19	8·19	8·18
20	*8·20*	*8·20*	8·19	8·19
30	*8·20*	8·19	8·19	8·18
40	*8·20*	*8·20*	8·18	8·19
50	8·18	8·17	8·18	8·19
60	8·17	8·16	8·16	8·17
80	8·16	8·15	8·16	8·16
100	8·15	8·14	8·14	8·14
150	**8·08**	8·11	8·10	**8·09**
200	**8·03**	**8·07**	**8·04**	**8·01**
300	**7·99**	**7·95**	**7·94**	**7·94**

Table LXXVI

*p*H *values from 0–200 m. depth at stations in South Georgia survey of December–January 1926–7 arranged in order of ascending phytoplankton values*

Station	134	130	138	126	135	127	128	136
Phytoplankton in millions of cells	0·005	0·006	0·007	0·084	0·112	0·187	0·241	0·276
Depth in m.								
0	**8·34**	**8·36**	**8·35**	**8·35**	**8·34**	**8·34**	**8·35**	**8·35**
10	**8·34**	**8·36**	**8·36**	8·17	**8·34**	**8·33**	**8·35**	**8·35**
20	**8·35**	**8·35**	**8·36**	*8·15*	8·28	**8·33**	**8·35**	**8·35**
30	**8·35**	**8·35**	8·26	*8·15*	8·29	**8·34**	**8·32**	**8·36**
40	8·29	8·28	8·27	*8·15*	8·25	**8·32**	8·27	**8·36**
50	8·26	8·25	8·22	*8·15*	8·26	*8·11*	*8·22*	8·23
60	8·20	*8·14*	*8·17*	*8·12*	8·25	*8·07*	*8·10*	8·22
80	8·14	*8·05*	*8·11*	*8·06*	8·17	*8·06*	*8·02*	*8·12*
100	8·15	*8·05*	*8·06*	*8·06*	*8·11*	*8·02*	*8·02*	*8·05*
150	*8·09*	—	*7·97*	—	*8·04*	*8·02*	*7·99*	*8·00*
200	—	—	*7·95*	—	*8·00*	—	—	*7·97* N

Station	133	129	151	132	125	137	131	124
Phytoplankton in millions of cells	0·323	0·430	0·800	1·116	1·317	1·8	3·328	11·06
Depth in m.								
0	8·22	**8·34**	**8·35**	**8·35**	**8·35**	**8·35**	**8·34**	**8·34**
10	8·22	**8·35**	**8·35**	**8·35**	**8·35**	**8·35**	**8·34**	**8·35**
20	8·22	**8·35**	**8·36**	**8·35**	**8·35**	**8·36**	**8·35**	**8·35**
30	8·22	**8·36**	**8·36**	**8·32**	**8·35**	**8·36**	**8·31**	**8·35**
40	8·22	**8·36**	**8·36**	8·27	**8·35**	**8·31**	**8·31**	**8·33**
50	8·22	**8·30**	**8·30**	8·22	**8·36**	8·27	8·26	**8·34**
60	8·22	8·22	8·25	*8·09*	**8·35**	8·21	8·21	**8·34**
80	*8·08*	8·15	8·25	*8·10*	8·24	8·15	*8·15*	
100	*8·06*	*8·10*	8·26	*8·02*	*8·10*	*8·10*	*8·09*	8·22
150	*8·00*	*8·03*	8·24	*8·01*	*8·01*	*8·03*	*8·02*	*8·04*
200	*7·97* N	*7·97* N	8·17	—	*7·96* N	*7·96* N	*8·01*	*7·98*

N = Night stations.

Attractive by its simplicity as is the idea that differences in alkalinity, due to varying degrees of photosynthesis, might modify vertical migration, we must recognize that such differences in alkalinity as we have observed hardly give it support. In Table XIV on p. 83 are shown examples of increased oxygen content in the upper layers due to increased phytoplankton production; but in the survey as a whole there is little correlation between oxygen and phytoplankton from station to station, as shown in Table LXXVII.

Table LXXVII

Oxygen values, cc. per litre, from 0–200 m. depth in South Georgia Survey of December–January 1926–7 arranged in order of ascending phytoplankton values. Values over 7·5 shown in heavy type

Station	WS 39	WS 42	135	WS 38	127	133	WS 33	WS 37
Phytoplankton in millions of cells	0·009	0·024	0·112	0·116	0·187	0·323	0·341	0·378
Depth in m.								
0	7·28	**7·61**	7·44	7·43	**7·51**	**8·02**	7·46	7·30
10	7·37	**7·63**	7·45	**7·56**	**7·60**	**7·64**	**7·60**	7·27
20	7·38	**7·50**	7·47	7·41	**7·62**	**7·65**	7·48	7·31
30	**7·55**	7·48	**7·54**	7·37	**7·64**	**7·75**	7·48	7·06
40	**7·51**	**7·64**	**7·60**	7·48	**7·78**	**7·77**	7·37	7·31
50	7·40	**7·73**	**7·53**	**7·50**	**7·60**	**7·65**	7·46	7·08
60	7·41	7·35	**7·53**	**7·50**	**7·55**	—	**7·52**	7·27
80	7·41	7·19	**7·53**	7·28	7·17	7·32	**7·65**?	7·14
100	7·30	7·40	**7·57**	6·88	6·90	6·97	7·17	7·31
150	6·85	6·10	7·21	5·15	6·59	6·20	—	6·61
200	5·68	—	6·07	4·62	—	—	—	6·09

Station	129	WS 61	WS 28	WS 51	137	WS 63	131	WS 52
Phytoplankton in millions of cells	0·430	0·458	0·550	0·582	1·800	2·614	3·328	4·643
Depth in m.								
0	**7·64**	7·31	7·39	7·41	**7·76**	7·24	7·43	7·36
10	**7·64**	7·25	7·41	7·43	**7·73**	7·16	7·45	7·25
20	**7·62**	7·24	**7·59**	7·34	**7·83**	7·23	**7·73**	7·27
30	**7·60**	7·19	7·42	7·43	**7·67**	7·25	**7·68**	7·26
40	**7·62**	7·23	7·40	7·36	**7·69**	7·26	7·48	7·32
50	**7·60**	7·25	7·42	7·39	**7·69**	7·36	7·44	7·26
60	**7·58**	7·27	7·10	7·32	**7·69**	7·31	7·48	7·21
80	**7·51**	7·13	7·14	7·35	7·49	7·15	7·36	7·09
100	**7·52**	6·41	7·12	6·93	6·92	7·06	7·41	6·89
150	6·81	5·45	—	6·08	5·96	5·87	6·76	6·37
200	5·18	4·52	—	4·66	5·11	4·95	6·11	—

Station	WS 35	124	WS 30	WS 45	WS 47	WS 44	WS 40	WS 49
Phytoplankton in millions of cells	8·259	11·06	18·26	99·05	126·1	143·8	193·3	531·2
Depth in m.								
0	7·30	**7·58**	**7·82**	**7·69**	7·34	7·46	**7·54**	**7·88**
10	7·46	**7·54**	**7·85**	**7·62**	7·39	7·36	**7·59**	**7·87**
20	7·25	**7·56**	—	**7·77**	7·39	7·33	7·19	**7·77**
30	**7·53**	**7·57**	**7·75**	**7·76**	7·33	7·29	7·49	**7·73**
40	7·26	**7·66**	**7·50**	**7·68**	7·41	7·28	7·45	**7·79**
50	7·34	**7·54**	7·48	**7·87**	7·36	7·29	7·41	7·36
60	7·19	**7·56**	**7·80**	**7·54**	7·42	7·18	7·35	7·34
80	7·43	**7·58**	**7·55**	**7·61**	7·42	7·20	7·26	7·25
100	7·07	7·38	**7·69**	7·31	7·21	7·05	7·14	7·09
150	—	6·47	6·48	5·93	6·17	5·80	5·69	6·20
200	—	5·46	4·94	—	—	4·91	—	4·96

Before proceeding to examine a further factor which might govern depth distribution let us consider the general significance of the phenomenon of vertical migration. No satisfactory explanation appears to have been given to account for it in terms of advantage to the organism. It is one of the commonest of pelagic phenomena, and is found in nearly all groups of planktonic animals. Invariably[1] the animals migrate upwards at the approach of darkness and downwards at the approach of daylight. There can be no doubt that the animals react in part to the stimulus of light. The phototropisms of planktonic animals have long been established, and it is well known that these tropisms may be changed from positive to negative under different conditions. Whilst usually it has been held that the animals are reacting to certain optimum conditions of light intensity, Clarke (1930) has shown experimentally that the fresh-water *Daphnia* reacts to certain rates of change in light intensity rather than to any fixed optimum intensity. Whilst it is desirable and necessary physiologically to study separately this and that factor to which the animal may be reacting, it is also desirable to look at the problem as a whole from the ecological standpoint. In our survey the many different animals which are making vertical migrations spend the greater part of the twenty-four hours at depths below 50, 100 or even 200 m. The herbivorous animals presumably come into the upper layers to feed on the richer phytoplankton, and the carnivores to feed upon the herbivores concentrated in these upper zones. As these animals move upwards into the phytoplankton zones they pass into a different environment, one more alkaline and richer in oxygen. Whilst we saw that the changes in alkalinity and oxygen from station to station within the upper layers may not be very great, the changes encountered in passing from depths below 100 m. to the surface may be considerable. It seems possible that these animals find conditions of living more suited to them down below than in the upper phytoplankton zones, and that they only make diurnal excursions into the upper zones for feeding for a comparatively short time. If conditions were just as suitable for them in the upper zones, where their food is, one might expect that they would remain there. Their preference for living in the lower zones may be due to the different chemical conditions of the environment such as those just referred to or others unknown, or it might possibly be due to the greater protection the darkness of the lower layers affords them against the attacks of predators. If they remained in the upper illuminated layers during the daytime they might more easily become the victims of attack. It would seem that vertical migration is primarily a movement towards and away from the upper phytoplankton pastures. If the animals usually avoid these upper zones because they find them chemically uncongenial, then should the phytoplankton crop become exceptionally low we might expect them to be able to remain longer in these zones, because the alkalinity, oxygen and other conditions set up by the phytoplankton would also be reduced. We have considered such little evidence as we have in this respect from our survey, and found it not very satisfactory. Now there is another possibility. Suppose the animals ascend and remain up for just so long as will allow them to get sufficient food to carry them over a further period in

[1] With the possible exception of the amphipod *Primno* discussed on p. 198.

the more congenial environment of the lower layers, then the more abundant the food in the upper layers the less time need they stay there; similarly the poorer the food the longer would they have to remain to gain sufficient sustenance. The food supply might be so poor that the animals might have to remain in the upper layers for the whole twenty-four hours. Clarke (1932) provides important experimental evidence in favour of this view from his study of fresh-water *Daphnia*. He writes:

> If the culture medium is allowed to "run out" or to become too dilute, it is found that the majority of adult *Daphnia* exhibit a positive phototropism, whereas when the culture medium is fresh and rich most of the animals are primarily negative to light.

It is well known that in the daytime the young stages of planktonic animals,[1] particularly Copepoda, tend to be higher in the water than the older and adult stages (cf. Russell, 1927*a*; Clarke, 1933; Gardiner, 1933, 1934; Nicholls, 1933). Again for the fresh-water *Daphnia* Clarke (1932) shows that the young "almost always exhibit a strong positive phototropism which becomes progressively weaker as the animals grow older"; the adults being usually primarily negatively phototropic. Young growing animals will need a more constant supply of food than will the adults, so that they may remain altogether in the upper layers, or may remain there longer than the older specimens.

Thus the food requirements of the animals may be a factor governing their depth distribution in relation to varying degrees of phytoplankton density. The condition of the animal, whether it is well fed or starved, may determine the phototropic sign of the animal, or in other words whether the animal is trying to reach the more illuminated upper layers for feeding. It is a common observation that from a sample of animals caught in a tow-net some individuals may be negatively phototropic, and others of the same species positively phototropic; there may be those which have had sufficient food and those which require yet more. Likewise we find that not all the individuals of a species come to the surface together; there are often a good proportion left below, at times sharply separated from those which have ascended (see Figs. 107 and 114). Some individuals in areas of rich phytoplankton may have been able to obtain sufficient food to enable them to remain below for two days. If this were so, then, by the differing speeds of the water layers, these animals would be carried more quickly away from the denser phytoplankton. In connection with this ecological conception of vertical migration being a journey from and return to a more congenial environment for purposes of feeding, mention should be made of the more mechanical ideas and experimental work of Eyden (1923) suggesting that changes in the specific gravity of the animal due to feeding in the upper layers must be taken into consideration when investigating the causes of vertical migration.

If the phytoplankton is a closely grazed crop, as Harvey's results indicate, then the withdrawal of the herbivores from the pastures during the hours of photosynthesis must be an important factor in maintaining the yield of the crop. Gran (1933) at Woods Hole found that diatoms, one month after mid-summer, made from five to seven divisions in three days, and Harvey's (1934) preliminary observations suggest that diatoms in the Plymouth area in April and May divide twice daily.

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[1] *Velella* is an interesting exception.

In the next section we shall see that changes in the extent of the vertical migration undertaken by animals will result under certain usual conditions of water movement in changes in their horizontal distributional density. We know that vertical migration does vary in extent from time to time, and if these changes were proportional to changes in the phytoplankton, then we should get just such a distributional arrangement of the animals as we have seen in relation to the phytoplankton.

The problem is one which must be attacked by the experimental method both in the field and the laboratory.[1] My colleague Mr C. E. Lucas has undertaken experiments to investigate the effects of different strengths of phytoplankton concentration upon plankton animals, as well as the rates of consumption of the phytoplankton by the animals. Whilst it is too early yet to give a full account of the experiments, which are still in progress, he has kindly allowed me to refer to two interesting series of results. In one set of experiments he had two long tubes, one filled with sea water without phytoplankton, and the other with sea water of the same character but containing a culture of *Nitzschia*, the strength of which was varied in different experiments. An equal number of Mysids was placed in each tube, and each tube was darkened for half its length by being covered with light-proof paper. Then at intervals he observed and recorded the numbers of *Mysids* showing themselves in the uncovered part of the tubes during the daytime. The following pairs of figures represent the numbers of *Mysids* seen in each tube during each experiment, those on the left refer to the diatom-free tube, and those on the right to the diatom tube. The number of observations in each experiment varied, but their average was eight.

18	4	17	8	26	15
12	8	3	8	57	25
10	7	65	49	11	7
11	0	39	22	22	3
9	4	4	5	59	58
19	5	46	22	44	60
12	2	6	0		

The experiments shown in the last column were made with young *Mysids*, the remainder with adults.

In another series of experiments he kept an equal number of Copepods or *Mysids* in a number of different jars containing sea water with increasing strengths of *Nitzschia*. He found in seven out of eight such experiments that the animals lived longest in ranges of intermediate phytoplankton. He will later publish a detailed account of the work when the experiments have been carried further.

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[1] Professor E. W. MacBride, F.R.S., has recently informed me, and kindly allowed me to mention, that in rearing Echinoderm larvae he has found that if the diatoms (*Nitzschia*) used as food multiply too rapidly to form a dense culture then the larvae die.

VERTICAL MIGRATION AND THE DYNAMICS OF DISTRIBUTION

The horizontal paths of movement of planktonic animals and plants in relation to the sea bed or the land will vary according to whether the animal or plant undergoes vertical migration. Organisms which have no vertical migration will simply be carried along in the one water mass they happen to be in, but the path of those undergoing vertical migration will be complicated by the differing speed and direction of the water layers between which they pass. The movements of the former need no special consideration; they are the same as the water movements. The present section will be devoted to a discussion of the movements and consequent distribution of vertically migrating animals[1] brought about by different current systems. In the area we are studying we have seen (on pp. 231–250) that vertical migration is an important characteristic of all but a few of the commoner plankton animals, and that the majority are moving between depths of at least 100 m. and the surface, and many are rising from considerably deeper levels. We shall see that not only will their movements be complicated by the current systems, but that their relative abundance in this place or that may be governed by the same systems. We can deal conveniently with the types of movement under three headings. Firstly, movements consequent upon both the speeds of the current systems and the extent of vertical migration remaining more or less constant. Secondly, movements consequent upon the speeds of the currents remaining constant but the extent of vertical migration varying, and, thirdly, those consequent upon a relative acceleration or retardation of the different water layers with the migration remaining constant or varying. Under the last heading will be included the acceleration or retardation of surface masses by the action of wind, and the retardation of lower masses by the contours of the sea floor.

In Fig. 6 on p. 10 we show a chart of the surface water movements around South Georgia kindly prepared for us by Mr A. J. Clowes by means of dynamic calculations; Mr G. E. R. Deacon has also kindly prepared one, Fig. 171, showing in less detail the general movements at a depth of 150 m. Neither hydrologist would regard these charts as exact, but they are as nearly correct as can be estimated from the data available. By considering both charts we can work out the approximate path that would be taken by animals migrating between 150 m. and the surface, assuming that the speed of the currents and the range of vertical migration remain more or less constant. Fig. 172 shows an example. It represents in plan an area to the north-east of South Georgia bounded approximately by latitudes 53° 20′ and 54° 20′ and longitudes 34° and 38° W. In this diagram, and the four which follow, the fine continuous lines represent the direction of the surface currents and the fine broken lines that of the lower currents, in this case those at 150 m. The heavy black lines represent the paths of vertically migrating

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[1] The term "animals" will be used rather than "organisms", because it is simpler to use frequently, and because so far we have only found one plant *Coscinodiscus* (see p. 45) to undergo vertical migration. But what is said regarding animals will apply equally well to plants similarly migrating.

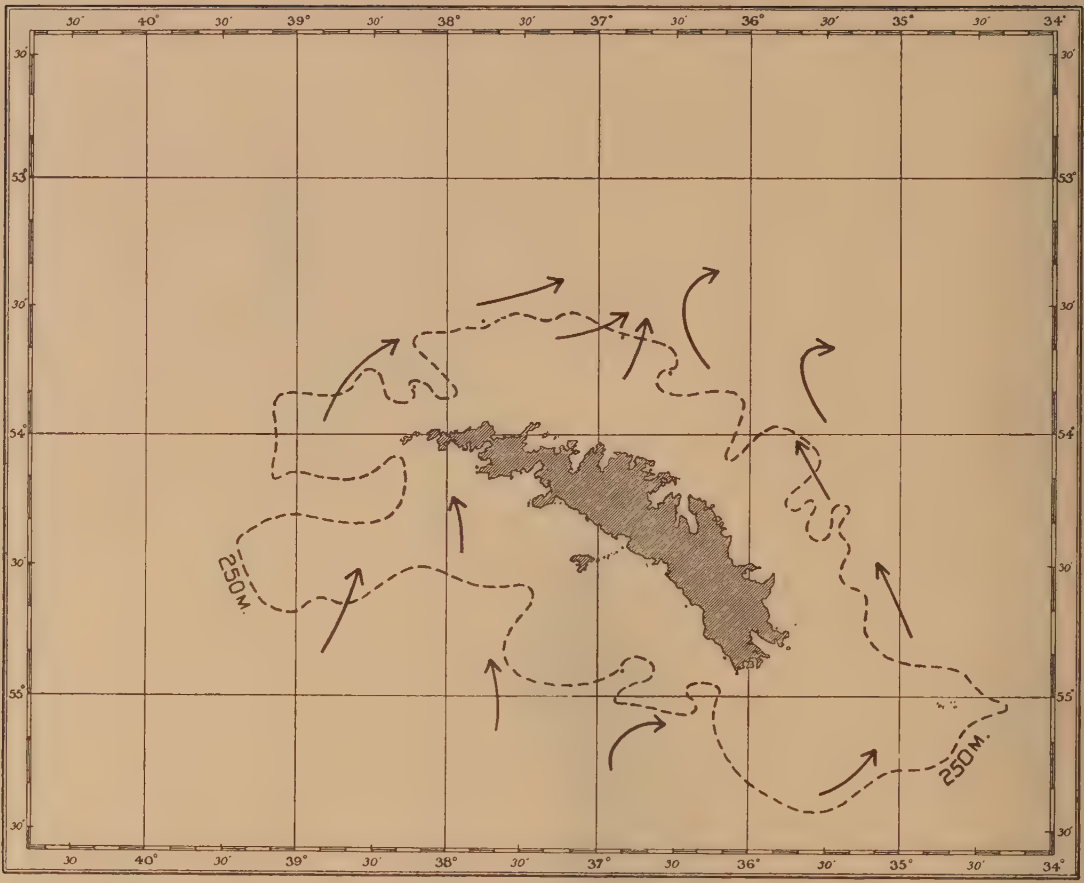
30'
40°
30'
39°
30'
38°
30'
37°
30'
36°
30'
35°
30'
34°
30'
53°
30'
54°
30'
55°
30'
250 M.
250 M.

Fig. 171.

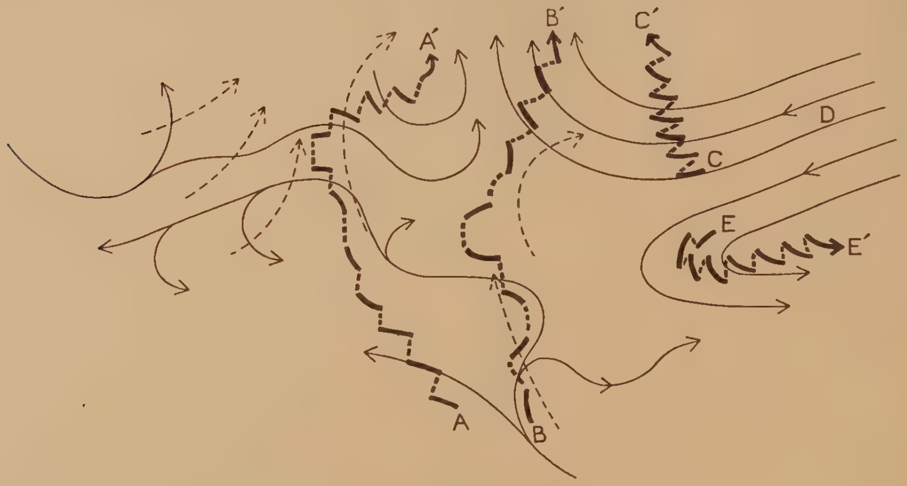

Fig. 172.

animals, the unbroken parts of the lines being their paths in the surface currents, and the broken parts their paths when below. If we start to observe an animal at *A* it will follow more or less the path to *A′* and *B* to *B′*. We see that at some points in their journey they may be carried farther apart than at others. The distance travelled in the surface current is shown as approximately equal to that travelled in the lower current. The surface current will likely be travelling faster than the lower one; but we have seen that the animals usually spend a shorter time in the surface layer and a longer time below. *C* will take the path to *C′* and *E* to *E′*. So we could pick out numerous examples of the possible movements of migrating animals from different parts of the region; it must be remembered that these considerations are theoretical and based on the assumption that the range of migration remains more or less constant.

We will consider two rather more special examples. Fig. 173 shows in a somewhat idealized form for the purpose of the diagram a surface swirl such as would seem to exist at the time of our survey to the west of the northern end of our island. It is not necessarily a vortex descending in the centre, but perhaps rather a disc of surface water rotated by the moving water masses at its periphery. The fine broken lines show the likely movement at 150 m. Now our vertically migrating animals will follow paths from *A* to *A′* and from *B* to *B′*.

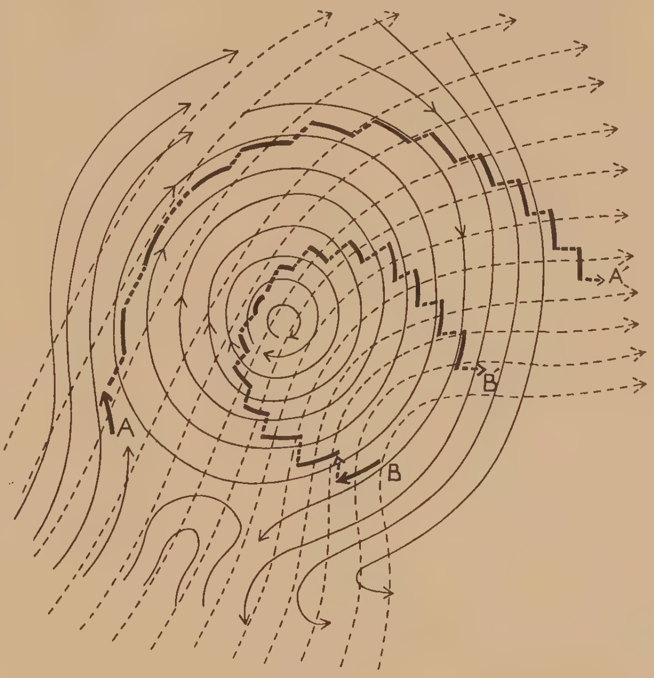

Fig. 173.

If a current in the southern hemisphere meets an obstruction it will tend to be curved round to the left; thus when two currents meet they may be deflected round in opposite directions. Now if the water of one current is perhaps warmer or less saline than the other, and so slightly less dense, it may, as it curves round, partly overflow the other, giving rise to a condition as shown in Fig. 174. This diagram, for demonstration, is again ideal rather than usual. Such completely symmetrical conditions may rarely be met with, but frequently they may approach it. In this ideal diagram an animal starting at *A* would pass to *A′* and back to *A* again, and one at *B* to *B′* and back to *B* again. It will be noted that the animals are shown as travelling longer or shorter distances for each sojourn in the upper or lower layers as they pass out towards or inwards from the periphery of the curving current. In this manner an assembly of animals might be kept circulating in one area whilst the water masses were continually passing on. In actual practice an animal would rarely be brought back to exactly the same place, but with swirling current systems as we see round South Georgia in the meeting and mixing of the two streams of Bellingshausen Sea and Weddell Sea origin, varying slightly in salinity and temperature, we may often get conditions which might hold assemblies of animals for considerable periods in one neighbourhood. The probable maintenance of patches of *Euphausia superba* in one place from one month to another has been demonstrated by the whale concentration charts shown in Figs. 155 and 156 on pp. 292 and 293.

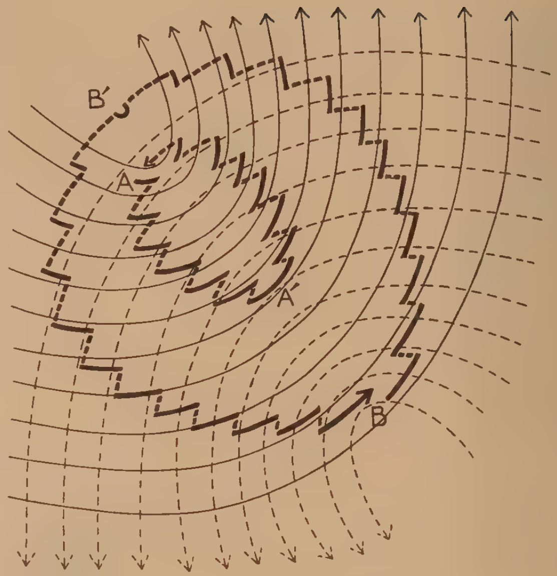

Fig. 174.

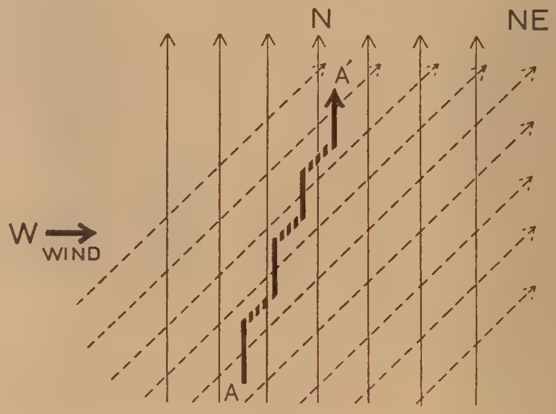

Fig. 175.

We may now consider the movements of vertically migrating animals in relation to surface waters moved by wind. In Fig. 175 let the main water mass—fine broken lines—be moving in a north-easterly direction. Now a west wind will have the effect[1] of causing the surface stratum to move at 45° to the main water mass, i.e. to the north, shown by continuous fine lines. Thus an animal starting at *A* will be moved under the influence of this westerly wind, not in a more easterly direction as one might first of all imagine, but in a path to *A′*. In Fig. 176 an easterly wind is shown acting upon a similar water mass moving to the north-east; the surface stratum is again deflected at 45° from the main water mass, but this time to the south, and an animal would move from *A* to *A′*.

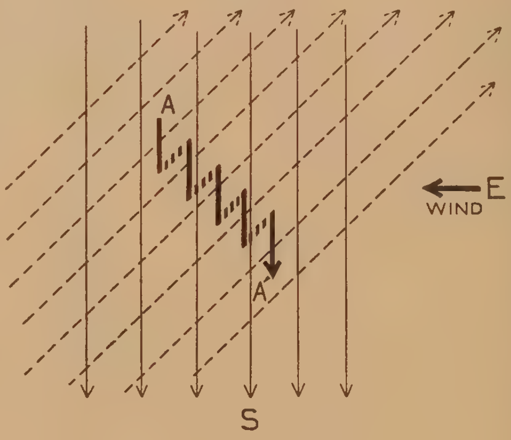

Fig. 176.

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[1] In the southern hemisphere. I am indebted to Mr G. E. R. Deacon for this information regarding the influence of wind in moving the surface stratum in relation to the lower mass.

Propositions concerning variable vertical migration

In a former section we have seen that a vertically migrating animal may remain higher in the water in the daytime on some occasions than on others; and whilst the evidence is not conclusive, there is some indication that this difference in level in the daytime may be due to differences in the phytoplankton concentrations in the upper layers. So similar is the natural grouping of the different plankton animals in respect on the one hand to their horizontal distribution in relation to the phytoplankton (as revealed by phosphate values), and on the other to their vertical migration, see pp. 312 to 313, that we are led to the conclusion that in some way the two are connected. In this section we will assume the hypothesis that the animals migrate more deeply in the daytime in areas of dense phytoplankton than in weak, and see what would be the effect upon their distribution if they are migrating between layers of water differing in speed. *It should be noted that similar effects will be produced if the animals remain down longer in time rather than descending more deeply.* Again, whilst we are assuming the phytoplankton hypothesis for the sake of simple description, it must be kept in mind that other factors, chemical and physical, may be producing similar results, so that for all the propositions outlined when phytoplankton is mentioned as a possible cause modifying vertical migration we should interpolate *or some other factor bringing about a similar change in the vertical migration.* Our series of propositions is based on the assumption that the animals come into the surface layer at night, but descend to different depths during the day. Exactly similar but reverse effects will be produced if the animals descend to a constant level but rise at night to different heights under different conditions; differences in the density of the water might bring about such differences in the extent of upward movement.

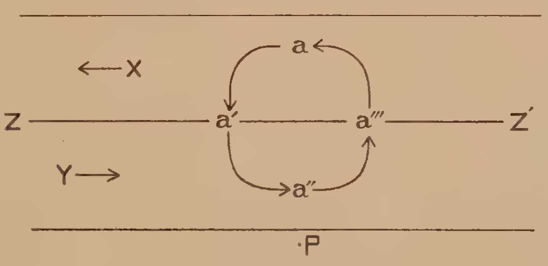

Fig. 177.

Let us first consider in Fig. 177 the movement of an animal *a* migrating between two water masses *X* and *Y* going at equal speeds in opposite directions separated by the line *ZZ′*. Let *X* be moving to the left and *Y* to the right. Let us observe the movement of *a* from a point outside the system, say on the sea-bottom at *P*, and let us assume that *a* makes a migration downwards at 6 o'clock in the morning and upwards at 6 o'clock in the evening, and let us begin our observations at midnight. During the 24 hours *a* will take up the points a', a'', a''', and come back to the point *a*; at a' it will be crossing from the water mass *X* to the water mass *Y* at 6 o'clock in the morning, and at a''' it will be returning from *Y* to *X* at 6 o'clock in the evening.

Now let us observe the same phenomenon from within the surface layer at *S* and for simplicity let us regard the layer *X* as stationary and the layer *Y* as moving. In Fig. 178, starting to observe again at midnight, *a* will follow the path *a*, a', a'', a''' to a_1 in the first 24 hours, at the end of the second day it will be at a_2, and at the end of the third day it will be at a_3.

Water masses in nature may not often be moving in opposite directions except at considerable intervals of depth, but they may often, in fact usually, be going at different speeds in the same direction, or very nearly the same direction, at quite small intervals of depth. The principle holds good for currents of *different speeds* in the same direction as for currents in the opposite direction. We have so far taken the simple but artificial instance of two sharply defined water masses separated by the line *ZZ′*. Actually the change of speed will gradually decrease or increase with the depth, more usually the former.

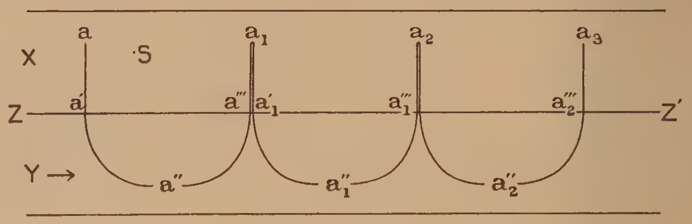

Fig. 178.

Mr Deacon has very kindly worked out for me the varying speeds of water masses at different depths between Sts. 137, 138 and WS 38 of our survey. They lie to the east of South Georgia, and are not far distant from the position at which the consecutive net experiment was made at St. 150. The speeds are as follows:

At	0	m.	5·5	miles	per day	to the	north
,,	25	,,	5·4	,,	,,	,,	,,
,,	50	,,	5·3	,,	,,	,,	,,
,,	75	,,	5·2	,,	,,	,,	,,
,,	100	,,	5·0	,,	,,	,,	,,
,,	150	,,	4·7	,,	,,	,,	,,
,,	200	,,	4·3	,,	,,	,,	,,
,,	300	,,	3·4	,,	,,	,,	,,
,,	400	,,	2·3	,,	,,	,,	,,

Since the majority of the zooplankton organisms in this area are normally migrating vertically through some 100–200 m. of water, these figures give an adequate basis for the propositions which follow. Mr Deacon writes regarding these calculations as follows: "I chose these stations because I had to make use of three stations made close together at about the same time. As it happens the choice is not fortunate because the deep current and the surface current seem to flow in the same direction towards the north. The effect of a strong wind might increase the surface velocity to 10 miles a day towards the NE, that at 25 m. to 7–8 miles a day towards the north, and the movement below 75 m. might be speeded up a little towards the east".

Although we know that actually under the influence of wind different layers within the depth of frictional influence (Ekman, 1928) will be travelling with decreasing speeds at gradually changing angles to one another, we will first regard the different layers as travelling in the same direction. Later we shall take the extreme case of currents flowing at right angles to one another, and show how the results of the former proposition would be modified. Let us consider four water layers *W*, *X*, *Y* and *Z* moving as in Fig. 179 from right to left with speeds of 5, 4, 3, 2 units per day respectively in relation to the sea bottom at *P*. Now in considering an animal migrating between these layers we want to understand its path within the system; i.e. in relation to the water layers rather than

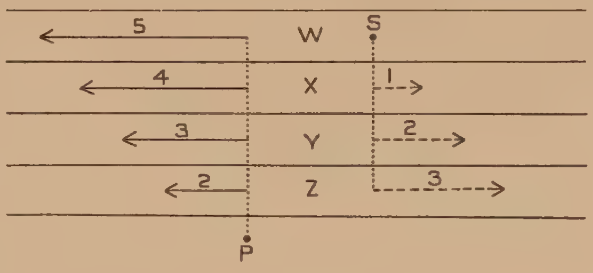

Fig. 179.

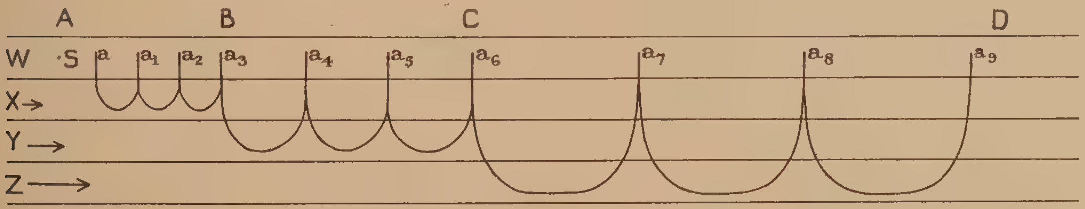

Fig. 180.

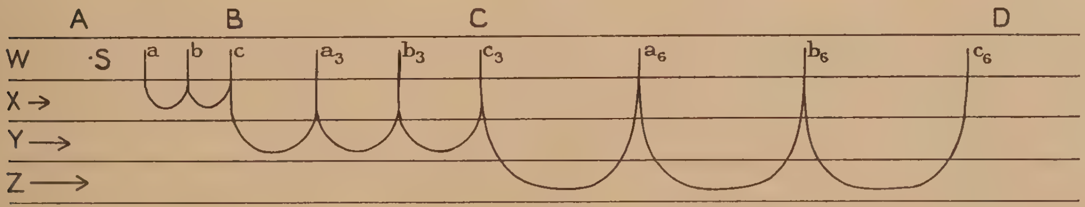

Fig. 181.

in relation to the sea bottom. If we consider its motion in relation to the bottom our task will be more complicated; we will first of all consider its motion in relation to one of the layers, the surface, and then if we wish to consider it in relation to the bottom we can, knowing the speed and direction of the surface layer, make a simple adjustment. It follows then in Fig. 179 that when we observe from a point *S* within the surface layer *W* the layers *X*, *Y* and *Z* will be moving in relation to the surface with increasing speeds of 1, 2 and 3 units per day in the *opposite direction* to their actual motion, i.e. they are being left behind by the point of observation in the surface layer. Such a system, with four water layers *W*, *X*, *Y*, *Z*, observed from the point *S*, is shown in Fig. 180. In this figure let us suppose that the density of the phytoplankton in the surface layer varies. Between *A* and *B* let there be a moderate concentration producing a vertical migration in the organism *a* in the layers *W* and *X* only. Starting our observations at midnight *a* will follow the path *a*, a_1, a_2, a_3 in the first three days. Now let us suppose that at *B* the phytoplankton concentration increases, so that *a* is caused to migrate during the day into layer *Y*; it will now follow the path a_3, a_4, a_5, a_6 to *C*. Now let us suppose there is a further increase in the phytoplankton making the organism *a* migrate into the layer *Z*, so that it now follows the path a_6, a_7, a_8, a_9. If now we consider the same set of conditions but consider three organisms spaced out at *a*, *b* and *c* in Fig. 181; in three days' time they will be at a_3, b_3 and c_3, and in six days' time they will be at a_6, b_6 and c_6. Now suppose the water mass *X* is travelling at 2 units of distance a day faster than *W*, and *Y* 2 units of distance faster than *X*, and *Z* 2 units of distance faster than *Y*, then between *A* and *B* the organisms *a*, *b* and *c* will be one unit of distance apart (because for half the 24 hours they are in the layer *W*); now at a_3, b_3 and c_3 in the region of greater phytoplankton concentration they will be 2 units of distance apart, so that for every unit of surface area in the region *BC* there will be half the number of organisms that there are for every unit of surface area in *AB*. Again in the region *CD* the organisms will be 3 units of distance apart, and there will be only one-third as many organisms per surface area as compared with region *AB*. The greater the phytoplankton concentration, assuming the hypothesis is correct, the fewer will be the zooplankton organisms per unit of surface area. This is what we have found in our survey. The organisms, it will be observed, are travelling faster through the regions of dense phytoplankton than through the regions of low phytoplankton. The greater the difference in speed between the water at the bottom of the organisms' migration and the water of the surface the greater will be the reduction in the numbers of such organisms per unit of surface area in regions of dense phytoplankton. Less commonly, perhaps under the influence of contrary winds, the surface layer will be travelling more slowly than the lower layers in relation to a fixed point on the sea bottom; no matter, the effect will be just the same in relation to the other layers, but in the opposite direction. In regions of still greater phytoplankton than those considered or met with in our surveys, it might be possible that organisms might be prevented from coming to the surface even at night, so that they would travel still faster away from the region.

Again, according to the hypothesis,[1] if we encounter a reduction in the phytoplankton at the surface the reverse of the process just outlined would take place; the organisms would become *nearer* together again, so that there would again be *more* per surface area than under regions of dense phytoplankton.

If the phytoplankton increases gradually and evenly over the whole area under consideration, the zooplankton would migrate more deeply, but the number of organisms per unit area would not be reduced, and similarly if the phytoplankton decreases gradually and evenly and the organisms migrate less deeply their numbers per unit area would not be increased; the reduction or increase of zooplankton organisms per unit of surface area would, according to the hypothesis, be dependent upon the uneven concentration of the phytoplankton in relation to movement of water layers.

Now let us consider what would happen if we pass from a region of moderate phytoplankton to a region of very poor phytoplankton, *so poor* that the zooplankton organisms we are considering may *remain* in the surface layers. For simplicity let us consider in Fig. 182 only two water masses *W* and *X*. Let us observe again at *S* in the surface layer *W*, which we will consider as stationary and the layer *X* as moving. Let the phytoplankton in the region *AB* cause the organism *a* to migrate between the layers of *W* and *X*, so that at the end of the fourth day it will reach a_4, having followed the path a, a_1, a_2, a_3, a_4; now let us suppose that at *B* it comes into the region *BC*, where the phytoplankton is so low that it remains in the surface layer *W*, migrating between the points *S* and *S'*. Now in Fig. 183 let us consider four organisms *a*, *b*, *c* and *d* occupying respectively the same positions as a_4, a_3, a_2 and a_1 in Fig. 182. At the end of a period of 24 hours they will be at the positions *a*, *b*, *c* and *d* in Fig. 184, *b* having joined *a* at *B*. At the end of two days they will be at the positions shown in Fig. 185. At the end of three days all four organisms will be together at *B* (Fig. 186). We should get a belt of zooplankton produced between the area of moderate and very poor phytoplankton. The water in the region *BC* of poor phytoplankton would be depleted of the zooplankton organisms held up at *B*. In our survey we find the zooplankton reduced in regions of poor phytoplankton. In Fig. 166 we have seen a belt of *Euphausia superba* along the edge of a zone of poor phytoplankton. These belts when once formed might become altered in shape by the action of currents, and become concentrated in patches. The concentration of Euphausians upon the coast of South Georgia in March 1926 might have been due to such a cause, for here the phytoplankton was poor and the Euphausians high in the water, being taken in surface nets during the daytime on several occasions, and it will be remembered (p. 273) that immediately outside the concentration there was a region devoid of them.

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[1] Whilst the phytoplankton hypothesis is referred to throughout this argument for simplicity, the qualifications set out on p. 347 must be kept in mind.

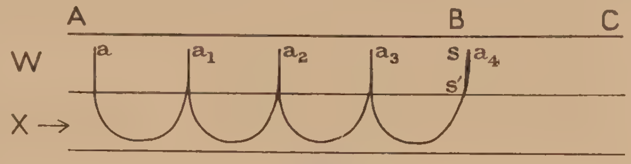

Fig. 182.

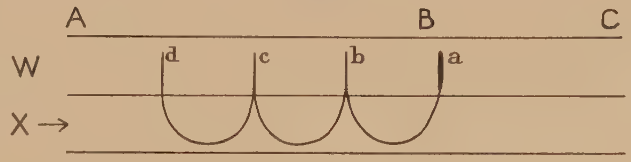

Fig. 183.

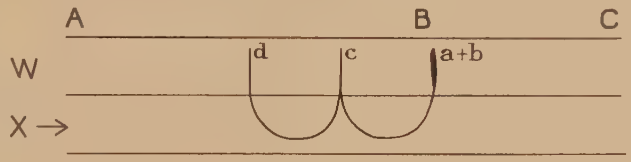

Fig. 184.

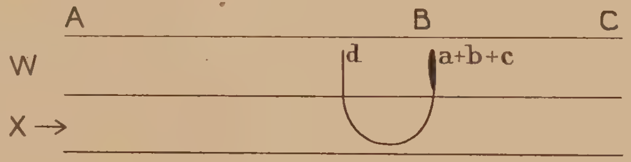

Fig. 185.

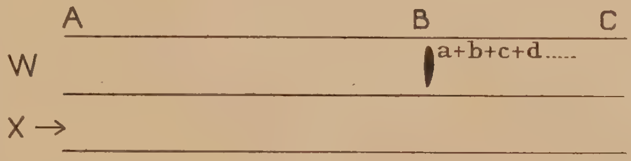

Fig. 186.

So far we have considered currents going in opposite directions or at different speeds in the same direction. Now let us consider the extreme, and in nature probably rare, alternative of currents travelling at right angles to one another. In our diagram (Fig. 187) we will view them in plan and observe the movements of organisms from a point within the surface current. Let the two water masses be *X* and *Y*, of which *X* is the surface current travelling in the direction *AB* and *Y* the under current travelling in the direction *EF*. Let us further suppose that the deeper we penetrate into the water mass *Y* the faster it is

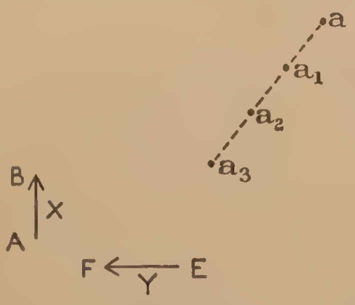

Fig. 187.

flowing in the direction *EF*. Let Fig. 187 represent moderate phytoplankton conditions, and let us observe at midnight an organism *a* migrating between *X* and *Y* then it will take up positions a_1, a_2, a_3 in the surface layer at the end of one, two and three days respectively. In Fig. 188 let the area of moderate phytoplankton *M* be separated from the region of dense phytoplankton *D* by the line *JK*, and let the dense phytoplankton cause the organisms to migrate deeper into the water mass *Y*, so that they travel faster in the direction of *EF*. The organisms *a* would now take up the positions a_1, a_2, a_3 under the region *M*, but would move to a_4 and a_5 under the region *D*. Again organisms would become fewer per unit of surface area under regions of dense phytoplankton than under regions of moderate phytoplankton. Now if we pass from a region of moderate phytoplankton to one in which the phytoplankton is so poor that the zooplankton organisms, according to the hypothesis, can remain in the surface layer, then we shall get a belt of organisms along the line *JK* between the two regions, just as we did in the example of currents going at different speeds in the same direction.

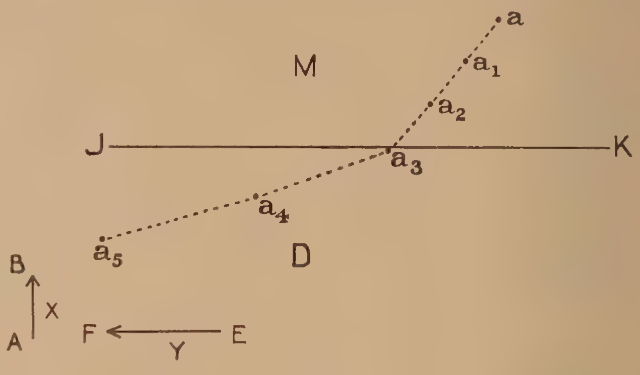

Fig. 188.

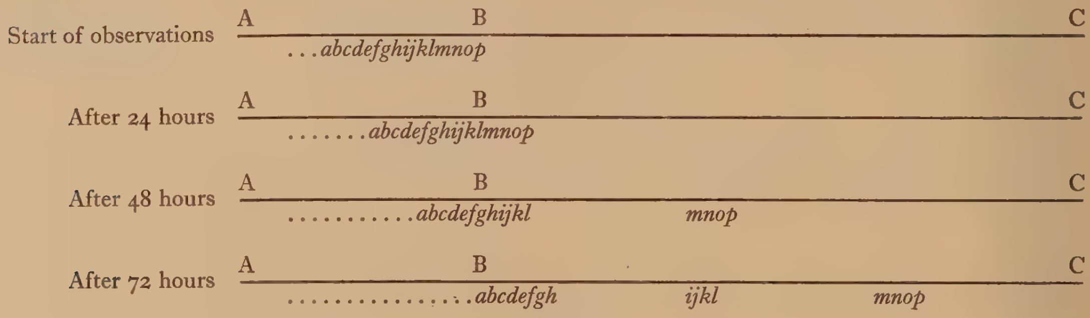

Fig. 189.

Now let us return to the consideration of the more usual conditions of currents flowing in the same direction at different speeds, and look at the matter more closely. So far in our diagrams we have only considered the movement of single organisms or of several organisms which are separated by distances equal to those which they travel in the course of 24 hours. Let us consider what will happen to a number of organisms close to one another. In Fig. 189 let the line *ABC* be the surface of the sea, and the portion *AB* represent a region of moderately low phytoplankton, and *BC* a region of comparatively high phytoplankton. Let *abcde...p* represent a number of organisms below the surface at midnight when we start our observations. Now suppose the phytoplankton under *AB* be such that these organisms make only a small migration vertically into water travelling just a little faster than the surface water, so that at the end of 24 hours they occupy the positions shown in the second line of the figure. The organisms *mnop* have been carried into the zone *BC* of denser phytoplankton; when they next go down they would penetrate much deeper than before into water travelling faster to the right, so they would be carried along as a group together, and will come up to the surface at the end of the second day in a group separated from the organisms *abc...l*. At the next vertical migration the group *ijkl* would become separated from *abc...h*. Thus we shall have a series of parallel belts of plankton at intervals at right angles to the current. Now this is a phenomenon which we have observed from the 'Discovery' on a number of occasions; particularly striking were parallel belts of *Pyrosoma* stretching across the sea, and possibly the patches of *Euphausia superba*, *Parathemisto*, etc., observed in the consecutive net series (Figs. 133 and 134), were in reality belts at right angles or making an angle with our direction of steaming. These consecutive net series were made off the north-east coast of South Georgia, where contrasts between zones of moderate and heavier phytoplankton may have been sufficiently sharp to produce this effect. If the organisms migrated upwards at 2100 o'clock and downwards at 0300 o'clock (as is more usual than 1800 and 0600 taken in our hypothetical examples previously), and the water into which they penetrated under moderate phytoplankton was travelling 200 yards a day faster than the surface water, and that into which they penetrated under the heavier phytoplankton 1 mile a day faster than the surface, then the belts of plankton would be 150 yards across and three-quarters of a mile apart. Such conditions would explain the type of patchiness met with in our consecutive net experiments.

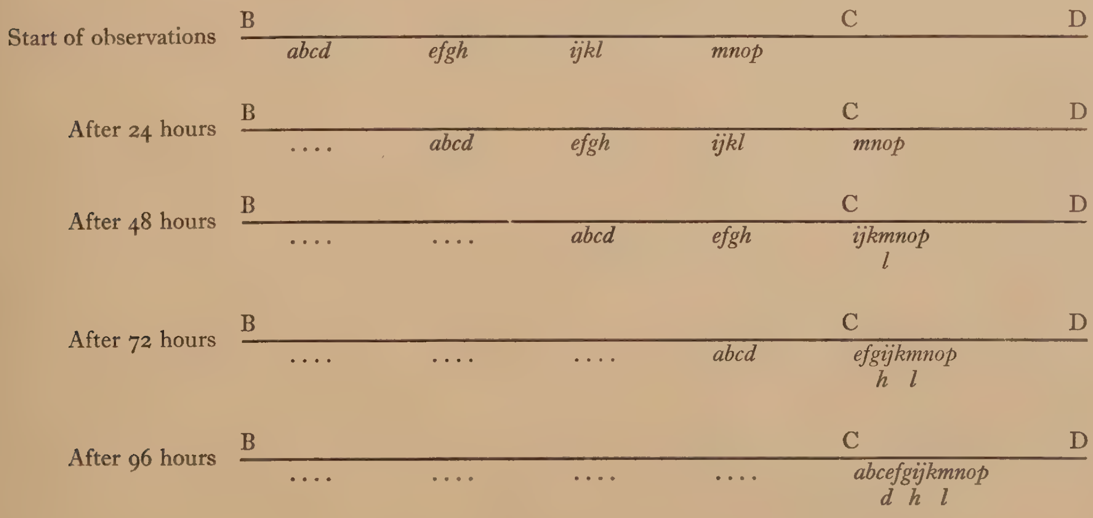

Fig. 190.

A series of such parallel belts of plankton passing from a region of dense phytoplankton to one of low phytoplankton would become closed up again; but if the speed at which they travelled under this new low phytoplankton concentration was less than that under the former low concentration, due to their not migrating so deeply, then the zones might not only close up but overlap to produce a further effect of uneven distribution, as shown in Fig. 190.

Most likely, when formed, belts of plankton would before long be broken up, so as to lose their form of parallel lines and appear as irregular patches. If parallel belts of plankton retained their form for some time and the phytoplankton causing them died down gradually over the area, then they would come to the surface in the form of belts in the daytime, if the phytoplankton had become sufficiently reduced. Such a hypothesis might account for the parallel belts of Salps seen in the daytime in sub-tropical waters.

It is likely that in nature the conditions will not be so hard and fast as those outlined for simplicity in the foregoing propositions; but a variety of changing conditions will merge into one another producing as a rule a less sharply defined effect.

If the hypothesis that the range of vertical migration may be determined by the phytoplankton production is correct, then the foregoing propositions would give an adequate explanation of the horizontal distribution of the different animals in relation to the phytoplankton such as we have found. The animals which have an extensive migration would show a separation from the dense phytoplankton, e.g. the macroplankton and the copepoda Group *A*. Those that remain longer in the surface layer and do not migrate so deeply would not be so separated, e.g. copepoda Group *C*, and might flourish in the zones of denser phytoplankton. Those which showed little or no regular vertical migration and only rarely come into the surface layers would not show any distributional relationship with the phytoplankton, e.g. the copepoda Group *B*. If a separation and aggregation of animals is brought about by differences in vertical migration, as we have just described, *but differences due to some other factor than the phytoplankton*, then the phytoplankton production might be modified accordingly by grazing (cf. Harvey, 1934).

Propositions concerning the acceleration or retardation of water layers

We will now consider the movements of an animal undergoing a more or less uniform vertical migration between water layers, one of which may be accelerated or retarded in relation to the other.

In Fig. 191 let a body of water be moving from left to right, and at the point *A* let the upper layer *X* increase its speed, perhaps under the influence of wind, but the layer *Y*

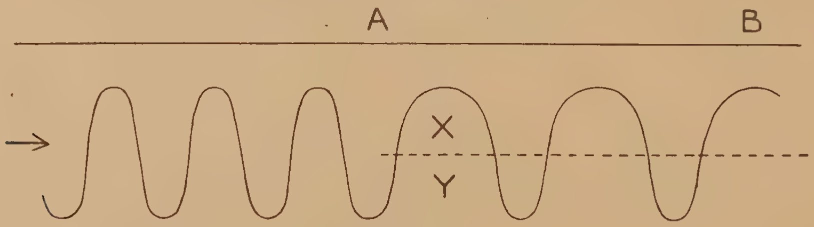

Fig. 191.

continue at its original velocity. Now a vertically migrating organism viewed from outside the system will follow the continuous curving line in the diagram; in the region *AB* for each ascent it makes it will be carried for a greater distance than formerly. The number of such animals below each unit of surface area in the region *AB* will be thus reduced, and the phytoplankton might be allowed to increase in this region. The same effect will be produced by an acceleration of the lower layer in relation to the upper layer.

In Fig. 192 let a body of water be similarly travelling from left to right, but now let the speed of the lower layer *X* be reduced to the region *AB*, perhaps on approaching a continental slope. The continuous curving line will now represent the path of a vertically migrating animal, and it will be seen that the numbers of such an animal below each unit of surface area in the region *AB* will be increased. A similar effect will be produced by a reduction in speed of the surface layer. If, as is usually so, the animal spends a longer time in the lower than in the surface layer, the retardation of the lower layer will produce a greater concentration of animals than will a retardation of the surface layer.

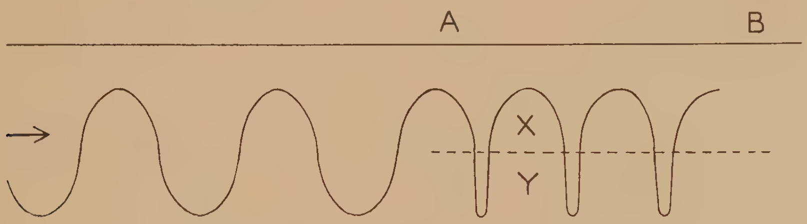

Fig. 192.

In these propositions we have considered animals with an unchanging vertical migration; if the vertical migration becomes altered at the same time as an acceleration takes place in one of the layers, the effect on distribution will simply be increased or diminished according to whether the change causes the animal to remain for longer or shorter in the accelerated or retarded layers.

As bodies of water approach an island such as South Georgia—or any land mass—or as currents meet in mid-ocean, such regions of acceleration and retardation may possibly occur and give rise to aggregations of a number of different species which have a similar vertical distributional habit, and to areas of comparative scarcity of animals in which phytoplankton might flourish. But it would seem that the separation and aggregation of animals caused by changes in current velocity may be very local and temporary in character, and whilst contributing to the general effect, it is thought that they would hardly give rise to the correlations of zooplankton with phosphate values, which suggest the gradual adjustment of distribution with the phytoplankton over a considerable period of time.

The object of submitting the propositions in these two sub-sections is to show what a potent agent vertical migration may be in the determination of plankton distribution, and to show that according to whether an animal has a marked vertical migration or not, so its distribution is related in general to the production of the phytoplankton in different areas—whether by the grazing activities as shown by Harvey (1934), by the vertical migration itself being modified by pre-existing differences in the concentration of the phytoplankton, or by both factors working together.

Planktonic "navigation"

We must note that zooplankton organisms which usually have a range of vertical migration over only some 200 metres will on occasion make much greater vertical movements. Particularly interesting are the deep-water concentrations of a number of Copepoda in the region of the Antarctic Convergence on the line between South Georgia and the Falkland Islands. There is a most marked concentration of *Calanus propinquus* at 750–1000 m. shown in Fig. 62 and lesser deep-water concentrations of *Calanus simillimus* (Fig. 59), *Ctenocalanus vanus* (Fig. 72), and *Scolecithricella minor* (Fig. 78), on this line, suggesting that these animals may use vertical migration as a form of "navigation" on a grand scale. It appears that these animals, on being carried by the surface layer to the limit of the Antarctic Zone, may descend, as a balloonist would from one air current to another, and make use of the great oceanic current system to return into the Antarctic Zone again in the intermediate layer flowing back towards the Pole. Fig. 62 suggests that a separate race of *Calanus propinquus* inhabits the sub-Antarctic Zone and is separated from the former race by the Antarctic Convergence.

Reassortment of the plankton

The consideration of vertical migration leads one to recognize that there must be a continual reassortment of animals within the plankton community. If organisms *A*, *B*, *C* and *D* are together at one night they may be considerable distances apart on the next night, if their vertical migrational range is different, and the speeds of the different water layers are not the same. Whilst the places of those passed on may be taken by others of the same species which have followed, often, owing to the patchiness of their distribution, the numbers of each different species brought together within a given volume of water on consecutive nights must vary considerably.

SOME DIFFERENCES BETWEEN THIS AND OTHER MARINE AREAS

Whilst this report is not the place in which to enter into elaborate speculations, it may not be altogether unprofitable to reconsider briefly some of the principal differences between this and other marine areas in the light of the discussion on the ecological relationship between the zoo- and phytoplankton. Temperature is usually thought to be the most important factor governing the character of the polar animal plankton, and this appears to be very reasonable; the alternative suggestions made in this section are put forward simply as hypotheses, which may perhaps serve the purpose of suggesting experiments and further observation in the field, which in turn might lead us either to new conceptions or to establish more firmly the realization of the domination of temperature.

The outstanding features of the Antarctic plankton may be summarized as follows:

1. The wealth of phytoplankton.
2. The small number of zooplankton species inhabiting the Antarctic surface layer, i.e. the top 150 m., the species which do so being very prolific.
3. The lack of pelagic larval stages of benthic animals (noting the exception of *Auricularia antarctica*).
4. The absence of a daylight surface fauna.
5. The importance of vertical migration.

The wealth of the phytoplankton in the surface layers is reflected in the rich deposits of diatom ooze on the floor of the Antarctic Ocean. The limit of this great zone of diatom ooze follows generally the line of the Antarctic Convergence.

We have seen that all the metazoan animals,[1] which occur in the upper layers in sufficient numbers to be investigated, show a marked vertical migration, except three species of copepod and the chaetognath *Eukrohnia hamata*, four animals which are only rarely taken in large numbers in the upper 50 m. The possibility is suggested that the animals find the upper phytoplankton layers uncongenial, and, whilst making feeding excursions into these layers at night, live for the greater part of the day below. If the surface layers are less congenial to the animals, temperature is not a factor contributing to this; we see that whilst the Antarctic surface layer—the top 150 or 200 m.—is as a whole much colder than the lower intermediate layer, the actual surface layers—the top 50 m.—are the warmer part of the layer, being heated by the warmer atmosphere in summer (see Figs. 5 and 7). The migrating animals spend the greater part of their time in the colder portion of the Antarctic surface layers, and the four animals just mentioned, which show little or no migration, live altogether in this colder portion.

Temperature has usually been held to be the main factor in limiting the number of zooplankton species in the polar seas. The line of the Antarctic Convergence separating the Antarctic Zone from the sub-Antarctic Zone is one marked by a sharp change in surface temperature between the two zones. This we may reasonably suppose is a very important, if not the most important, factor in limiting the ranges of different animals occurring *on each side of this line*, but we do not know that temperature is the most important factor in limiting the number of animal species which may successfully inhabit the upper layers of the Antarctic Zone. Temperature does not appear to limit the number of plant species; we note that the phytoplankton of the Antarctic is not only rich in its numbers of individuals but also in its variety of forms. The benthic fauna of the Antarctic, correlated no doubt with the luxuriant phytoplankton above it, is remarkably abundant, perhaps more prolific than anywhere else in the world; like the Antarctic animal plankton, it is rich in numbers of individuals, but in contrast it is also remarkable for the number and variety of the different species represented. This great wealth of benthic life has been commented upon by the naturalists of nearly all expeditions visiting the Antarctic since those of the 'Challenger' first drew attention to it. Here on the sea floor the animal life is bathed by the cold polar bottom water, so that temperature in itself would hardly appear to be a factor limiting the number of species. May we not tentatively keep in mind the possibility that the abundance of phytoplankton which may develop in any part of the region is a limiting factor, and that only a comparatively small number of species have been able to adapt themselves to the conditions, which may necessitate them making extensive daily excursions from the more congenial layers into the less congenial layers for feeding. Those which have done so occur in enormous numbers. Vertical migration is certainly much more pronounced in this region than in temperate regions, and temperature appears to be an unsatisfactory explanation. All but a small proportion of the large number of species of Copepoda recorded from our region have been taken in the intermediate layer, which whilst being the warmer layer is also well below the phytoplankton zone (see Fig. 54 on p. 122).

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[1] The protozoa have not been investigated for vertical migration within our area.

When the benthic fauna is so rich in numbers of species it is a surprising fact that so many of these animals, whose relatives in lower latitudes send up pelagic larvae, should bring forth their young by direct development, often in brood pouches. The almost complete absence of benthic larval forms has also been commented upon by naturalists of many Antarctic expeditions. The small larval forms would scarcely have the power to undertake the extensive vertical migrations which appear to be imposed upon the zooplankton inhabiting the upper layers.

In the tropics and the sub-tropical waters we find a large assembly of animals such as the floating siphonophores and the heteropods, which live at or near the surface in bright sunlight but are not found in the temperate and polar seas. We may note that only representatives of the Calycophorid siphonophores, which depend upon locomotion rather than flotation for support, extend into the polar regions: e.g. *Dimophyes arctica*, *Diphyes antarctica* and others recorded on pp. 105–106. In our survey only two specimens (*Pyrostephos vanhoffeni*) were taken in the top 50 m. in the Antarctic Zone, and these were taken on different occasions *but at night*. It is remarkable that a few of the surface tropical pelagic animals have not relatives which have become acclimatized to colder latitudes. We have seen that phosphates are usually absent, or present in only very small quantities, in the tropics (see Table VI[1]), so that the phytoplankton production must also be very low, as indeed has been shown by Lohmann (1920) and Marshall (1933). It seems possible that these forms have been able to evolve as daylight surface forms in these regions for just the same reason that in temperate regions zooplankton organisms may come to the surface in bright sunlight towards the end of the summer, when the phosphate content, and consequently the phytoplankton, is reduced. It is somewhat of a puzzle to know how these tropical surface animals are able to maintain their life with an apparently inadequate phytoplankton. Just as the nutritive salts are taken from the water by the phytoplankton and handed on to the animal plankton in the seasonal changes from spring to summer in the temperate seas, so it would seem there must be

[1] P. 77.

nutritive chains of animal organisms, carried in the ocean currents, conveying these substances from the temperate regions of phytoplankton production to the tropical zones of low nutritive content. Fig. 193 shows diagrammatically the two series of events, phenomena which appear to be the same, the one in a time and the other in a space dimension. Each with a reduction of "free" phytoplankton shows a change to a condition when animal plankton may be found in abundance at the surface in bright sunlight. In each we must suppose that the nutritive substances taken from the water by phytoplankton are handed on in a chain of animal organisms shown in the diagram as *ABC* and *D*, *B* feeding on *A*, *C* on *B*, *D* on *C*. It is well known that when planktonic animals die and sink the nutritive salts are returned to the water of the lower layers by the action of bacteria, to be brought to the surface in temperate regions by the water disturbances of autumn and winter, or by upwelling, and in our other wider example to be carried back towards the Pole by the warm intermediate current.

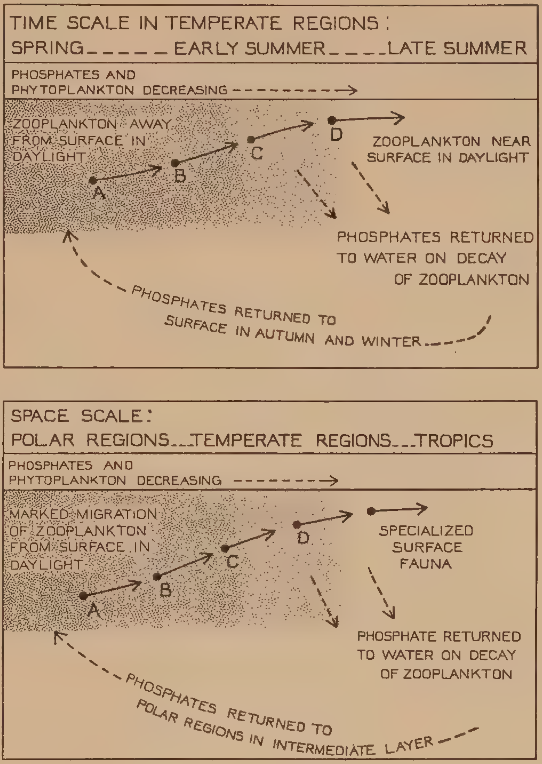
TIME SCALE IN TEMPERATE REGIONS:
SPRING — — — — EARLY SUMMER — — — LATE SUMMER
PHOSPHATES AND PHYTOPLANKTON DECREASING
ZOOPLANKTON AWAY FROM SURFACE IN DAYLIGHT
A
B
C
D
ZOOPLANKTON NEAR SURFACE IN DAYLIGHT
PHOSPHATES RETURNED TO WATER ON DECAY OF ZOOPLANKTON
PHOSPHATES RETURNED TO SURFACE IN AUTUMN AND WINTER
SPACE SCALE:
POLAR REGIONS — TEMPERATE REGIONS — TROPICS
PHOSPHATES AND PHYTOPLANKTON DECREASING
MARKED MIGRATION OF ZOOPLANKTON FROM SURFACE IN DAYLIGHT
A
B
C
D
SPECIALIZED SURFACE FAUNA
PHOSPHATE RETURNED TO WATER ON DECAY OF ZOOPLANKTON
PHOSPHATES RETURNED TO POLAR REGIONS IN INTERMEDIATE LAYER

Fig. 193.

If this comparison between the events in space across the world from the polar regions to the tropics and the events in time between spring and late summer in the temperate regions is a correct one, then the chain of animal organisms *ABCD*... in the former case must be an exceedingly long one. The expression "free phytoplankton" was used above because we must not overlook the rôle played by the symbiotic algae of the Foraminifera (*Globigerina*) and the Radiolaria. It seems possible that these organisms may play a much more important part in the economy of tropical seas than is usually attributed to them, in that they may assist in prolonging the transference of nutritive substances in the animal organisms over vast stretches of the ocean. If the suggested hypothesis is correct, that phytoplankton creates an uncongenial environment, it is possible that these animals, like the corals and many other animals which live in the upper zones of the tropical seas and which have symbiotic algae, have by imprisoning the phytoplankton been able to overcome the excluding influence by some counteracting physiological process, and the imprisoned phytoplankton in turn are able to obtain from their hosts the phosphates and other nutritive substances which are lacking in the tropical waters. The possibility of skeleton formation being such a counteracting physiological process has been mentioned on p. 335. The greater deposition of carbonate by organisms in warmer waters is another important biological character distinguishing the tropical from the polar regions.

As we pass from the polar regions through the temperate to the sub-tropical and tropical seas we pass, broadly speaking, from the regions of high nutritive salt content and rich "free" phytoplankton with apparent exclusion effects to regions of very low nutritive salts content and "imprisoned" (symbiotic) phytoplankton without the effects of the exclusion of the animal plankton from the sunlit surface layers. It may be significant that radiolarian ooze is found only under stretches of the tropical Pacific Ocean and part of the Indian Ocean, but not on the floor of the Atlantic Ocean, suggesting that the Radiolaria may be more prolific and fill an ecological gap in the water which has travelled a longer distance from the temperate regions of greater free phytoplankton production, the distances travelled by such water in the Atlantic Ocean being very much less. The sequence of deep-sea deposits encountered as one passes from the polar regions to the tropics in the wide Pacific Ocean, i.e. diatom ooze, globigerina ooze and radiolarian ooze, may reflect a fundamental change in the condition of the surface water as it is carried over great distances away from regions of predominantly "free" phytoplankton to regions of predominantly "imprisoned" phytoplankton. Darwin was dissatisfied with temperature as a factor governing the distribution of coral reefs; although highly speculative it is perhaps worth keeping in mind the possibility that their distribution may be associated with water masses which by currents have travelled farthest from the predominantly "free" phytoplankton regions, or perhaps more reasonably that they occur in water in which the "free" phytoplankton never or only rarely reaches a concentration sufficiently high to bring about exclusion effects. Marshall (1933) has recently shown that the "free" phytoplankton production of the Great Barrier Reef region is very low. Orr (1933), in describing the physical and chemical conditions in the waters of the Great Barrier Reef region, writes: "There is apparently seldom a complete lack of either of these salts (phosphates and nitrates), so that plant life is always present; the quantities, however, are too small to allow of a striking outburst of growth, such as is characteristic of temperate seas". Coral reefs are not found on the south-western coasts of Australia or the west coasts of North and South America, or on the eastern islands of the Pacific, and, like the radiolarian ooze, typical coral reefs are not found in the smaller Atlantic Ocean, and those that are found there are bathed by water which has travelled farthest from the temperate regions in the north and south equatorial currents.[1] It may be that there are relevant conditions in the water, chemical or ecological, which are only indirectly linked with the reduction in phytoplankton density.

These suggestions are only put forward in the hope that the critical consideration and likely rejection of new hypotheses may lead to fresh observations and experiments, which will ultimately furnish us with a better understanding of the ecological relationships between pelagic animals and plants.

[1] Since this was written I find that Potts (1923) associated the distribution of coral reefs in the Pacific with ocean currents and points out the progressive impoverishment in the number of coral species met with as the ocean is crossed from west to east. He regards, however, the influence of the currents to be one of temperature.

GENERAL SUMMARY AND CONCLUSIONS

This report is intended to form an introduction to the pelagic ecology of the Antarctic seas. The plankton community is considered in relation to its hydrological background, and to the distribution of the Blue and Fin whales which feed upon the plankton and form the object of such an important fishery in these seas. The particular area chosen for this study, the whaling grounds of South Georgia, is situated geographically well outside the Antarctic Circle, but hydrologically well within the Antarctic Zone. Whilst intensive work was carried out in the immediate region of South Georgia, lines of observation were made across the Antarctic Convergence into the sub-Antarctic Zone in two directions.

The horizontal and vertical distribution of the plankton has been studied in detail with three main objects in view:

(1) To find out which are the more important species in the plankton community and their relative abundance.

(2) To describe the actual distribution of these species at the time of the survey for comparison with surveys in later years.

(3) To obtain as far as possible a knowledge of the behaviour of the different organisms and the factors, physical, chemical and biological, governing their lives.

In fulfilling the first two of these objects much space in the report is necessarily occupied with a description of the distribution and relative abundance of the different species. It is evident that beyond satisfying the first of the objects a mere description of the distribution in itself is of entirely latent value until it can be compared with a number of future surveys. A few weeks earlier and a few weeks later the pattern of distribution will have been, at least in part if not entirely, different from that at the time of the survey; it will have been changed by the flow of ocean currents, the growth or decline of the phytoplankton and a number of other factors. Nevertheless, the detailed study of the component elements of the plankton community at any one phase of distribution, no matter what pattern that distribution may have, and their correlation with various environmental factors, is of immediate value in revealing to some extent the comparative behaviour of different organisms, and in bringing to light general principles governing planktonic life. The numerous charts illustrating the horizontal and vertical distribution of the more important species show the type of distribution which the different species may have, and considered together present the "anatomy" of the plankton community at one particular period. This summary, in briefly describing the contents of the report in order of their treatment, will pay particular attention to those points which may be of general interest to the marine biologist, and form a guide to the parts of the report in which they are dealt with.

Part I, in addition to the introduction, deals with the geography and hydrology of the area (pp. 3–16), the methods of collecting in the field (pp. 17–19), the cruises undertaken (pp. 19–24), the laboratory methods and their degree of accuracy (pp. 25–38). The degree of refinement in plankton analysis which may be warranted both by the conditions in the field and the nature of the survey attempted is discussed in detail.

Part II deals with the phytoplankton. A list of species indicating those of greater importance is given on p. 41. The distribution of the different species is described (pp. 42–64) and their relative abundance considered (pp. 64–65). The diatom *Coscinodiscus* appears to make a vertical migration towards the upper layers during the daytime and away from them at night (pp. 45–46). The phytoplankton communities of the different regions within the area examined are compared (pp. 65–76) and five different types, called "phytoplankton groups", are recognised within the area examined. A marked change in the phytoplankton is recorded in passing from the Antarctic to the sub-Antarctic Zone (pp. 75–76). The production of phytoplankton in relation to hydrography is discussed (pp. 76–87). Attention is drawn to the high phosphate content of the Antarctic waters which cannot be a limiting factor to production (pp. 76–77). The distributional pattern of phytoplankton production bears a close correlation with that of the reduction in phosphate content of the water and a lesser correlation with increased oxygen content is demonstrated (pp. 80–85). Various factors governing the production of phytoplankton are considered and a hypothesis relating such production with the mixing of waters of different origin is put forward (pp. 85–86). The seasonal changes in the phytoplankton are briefly discussed (p. 87). Twenty-five species of phytoplankton common to the northern and southern hemispheres are recorded from our collections (p. 87).

Parts III and IV deal with the zooplankton. A list of species indicating those of greatest importance is given on p. 89. A comparison is made of the composition of the catches of the different nets employed (p. 92). The horizontal and vertical distributions of the different species are described in the order given in the foregoing list (pp. 93–230). Where possible notes on their general natural history are included. An increase in the number of species of Copepoda at different levels descending from the surface to 750 m. is clearly demonstrated (p. 121). An association is shown to exist between the amphipod *Vibilia antarctica* and *Salpa fusiformis* (p. 199). The importance of *Euphausia superba* in the economy of the Antarctic seas is discussed in the light of past and present records (pp. 208–210). The swarming of these Euphausians was observed in the fjords (p. 210). Abundant evidence regarding the nature and extent of the vertical migration of the more important species of zooplankton organisms is provided (pp. 231–253). Nearly all organisms inhabiting the upper 250 m. of water display such migrations, notable exceptions being the Copepoda *Calanus acutus*, *Rhincalanus gigas* and *Oithona frigida*, and it is noteworthy that these organisms are taken only rarely in the top 50 m. (p. 241). The Copepoda *Pareuchaeta antarctica*, *Scolecithricella minor*, *Pleuromamma robusta*, *Metridia gerlachei*, *M. lucens* and the Euphausians *E. frigida* and *E. triacantha* are shown to make very extensive and rapid vertical migrations, which appears to preclude the possibility of locomotion itself being sufficient to account for them (pp. 236–240). Experiments with series of consecutive net hauls demonstrate a remarkable patchiness in the distribution of a number of forms, notably in *Euphausia superba*, *Parathemisto* *gaudichaudi* and *Salpa fusiformis*, but also to a less extent in others (pp. 254–265). The seasonal changes in the zooplankton are briefly discussed (p. 265). The plankton in the surface layers is considered in relation to rough weather and evidence is given to show that the state of the sea has little or no bearing on the number of organisms in the surface layers (p. 268). The possibility of a lunar influence on the plankton is considered (p. 268). The distribution of the zooplankton appears to be independent of the different phytoplankton communities found (p. 230).

Part V deals with the plankton in relation to the whale fisheries, the ecological interrelationship of phytoplankton and zooplankton, and the mechanism of plankton distribution.

The distribution of both Blue and Fin whales during their sojourn in Antarctic waters is shown to be closely correlated with that of their food *Euphausia superba* (p. 273). The factors determining the distribution of *E. superba* within the area are considered; temperature and salinity do not offer a satisfactory explanation (p. 277). The Euphausians appear to be distributed away from the areas of dense phytoplankton production (p. 277). Former work on the influence of phytoplankton concentrations upon fish and planktonic life is reviewed (pp. 277–279). The stations at which nets for the capture of macroplankton organisms were used are arranged in order of ascending phytoplankton values, and the numbers of macroplankton taken are shown to be greater at stations of medium phytoplankton values than at those of low or high values (p. 281).

Since (*a*) reduction in phosphate content of the top 50 m. of water has been shown to correspond with phytoplankton production over a little time in the past (p. 285), and (*b*) phytoplankton production appears to be inversely correlated with the distribution of *Euphausia superba*, and (*c*) the distribution of the Blue and Fin whales is closely bound up with the distribution of *E. superba*, it appeared to be possible, if the correlation in "*b*" were true, to deduce in future surveys the distribution of the whales direct from a knowledge of the phosphate values. Records of phosphate values together with whale distribution charts are available from three later South Georgia surveys and one South Shetlands survey. In each survey the whale distribution was deduced from the phosphate values and the theoretical result compared with the actual results from whale fishery returns; a good degree of correlation is obtained for both Blue and Fin whales (pp. 285–296). *p*H values were also used in conjunction with phosphate values. On another survey where phosphate observations were not made but phytoplankton samples were taken, the distribution of the phytoplankton was deduced from that of the whales and found to agree with the results of analysis (p. 297). The correlations obtained in these different surveys provide evidence of a distributional relationship between phytoplankton and the Euphausians, and the governing of the whale distribution by the latter. In the course of this discussion the influence of ocean currents upon patches of plankton is briefly considered (p. 291).

Relative reduction in phosphate content appears to be a better index in studying the zoo-phytoplankton relationship than the phytoplankton itself (p. 300). It gives a measurement of phytoplankton over a little time in the past. All zooplankton organisms occurring in sufficient numbers are now correlated with phosphate values. All the organisms show, in general, reduced numbers in the regions of low phosphate values except the Copepoda *Calanus acutus*, *Rhincalanus gigas* and *Oithona frigida*, which appear to be unaffected, and certain organisms which appear to prefer these regions: *Calanus simillimus*, *Drepanopus pectinatus* and *Antarctomysis maxima* (pp. 301–308). These results are confirmed in different series of nets.

The appearance of exclusion from regions of low phosphate (high phytoplankton) is shown to apply to animals belonging to such widely different groups as Foraminifera, Radiolaria, Polychaeta, Crustacea, Molluscs, and Tunicates. It is considered that if the distribution of the animals is being modified by the phytoplankton, then this modification must be brought about by variations in the vertical migration in conjunction with differing water movements at different levels (p. 311). All the animals which show the exclusion effects are shown to have a marked vertical migration; the three copepods which show no such effects have little or no vertical migration, and are rarely taken in large numbers in the upper phytoplankton zones. *Calanus simillimus* and *Drepanopus pectinatus*, which show a preference for rich phytoplankton in their horizontal distribution, are the two species of copepod which are found higher in the water than any other (p. 312). Depth of water in relation to vertical migration is considered as a possible cause of the effects produced, but similar results in general are obtained from shallow and deep-water stations (pp. 314–320). Further considerations suggest that it is possible that *Euphausia superba* may be a key organism controlling the phytoplankton by its feeding, and that the other animals may be adjusting their distribution to the resulting phytoplankton densities (p. 319). Vertical migration is considered in relation to phytoplankton, and the hypothesis of a modification of migration by phytoplankton examined. The evidence is suggestive but not conclusive (pp. 322–339). The general significance of vertical migration is considered (p. 340). Theoretical considerations regarding the combined effect of vertical migration and different current systems are described (pp. 343–356). Some of the main differences between the Antarctic and other pelagic areas are considered, and a hypothesis concerning the influence of the phytoplankton tentatively suggested (pp. 356–360). The distribution of coral reefs is briefly referred to (p. 360).

ADDENDUM (referring to footnote on p. 279). Since going to press we see that W. E. Allen (1934, p. 176) writes as follows: "It is possible that certain kinds of diatoms may be poisonous to animals (or to certain animals) just as land plants are known to be so, and it is possible that when present in great abundance they may interfere more or less with respiration of some animals by clogging the gills.[1] Direct evidence is not available in Southern California except that commercial fishermen say that fishing is not good where diatoms are so abundant as to discolour the water." He also refers to Torrey (1902) who records that abnormal swarms of Dinoflagellates (*Gonyaulax*) may cause great destruction of inshore forms of animal life.

[1] See also Hardy (1924, p. 34).

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APPENDIX I

PHYTOPLANKTON TABLES

Analyses of phytoplankton samples collected with the N 50 V net hauled from 100 m. to the surface. Only the more important species are shown, the details of occurrence of the less important species being given in the text. The numbers of organisms are expressed in **thousands**. The stations in the December–January 1926–7 survey have been arranged according to the grouping shown in Fig. 35, p. 69, so that the character of the plankton within these groups may be compared. Fig. 35 may thus be used as a key to the position of stations in the table. The numbers of the more important species within each group are shown in heavy type. The details of date, hour, position and sounding for each station are given in Appendix II, Table I. Full details of the meteorological and hydrological conditions will be found in the Station List, *Discovery Reports*, I, pp. 1–140.

Phytoplankton Tables. *See foregoing explanation, p.* 371.

Grouping of stations	South Georgia, March, 1926			Phytoplankton Group 1				Phytoplankton Group 2						—
Station	**23**	**31**	**41 C**	**161**	**WS 67**	**160**	**WS 63**	**WS 46**	**WS 47**	**WS 48**	**WS 49**	**WS50**	**WS 52**	**WS 30**
Fraction of sample examined	1/100	1/100	1/300	1/6000	1/100	1/100	1/300	1/150	1/3000	1/3000	1/1000	1/300	1/300	1/1500
Coscinodiscus bouvet	—	—	—	—	—	—	—	—	3·0	3·0	1·0	—	—	—
C. curvatulus	—	—	1·2	—	—	—	—	—	—	—	—	—	—	—
C. kerguelenensis	—	—	—	—	0·1	—	1·5	—	—	—	—	—	0·6	—
C. lineatus	—	—	—	1·8	—	—	1·8	0·15	—	—	—	—	—	—
C. occuloides	—	—	—	—	—	—	0·3	—	—	3·0	2·0	—	—	—
C. oppositus?	0·6	0·2	1·5	12·0	—	0·2	5·7	0·9	—	—	—	—	1·2	—
C. sub-bulliens	—	—	—	—	—	—	—	—	—	3·0	5·0	0·6	—	4·5
Asteromphalus brookei	—	—	—	—	—	—	—	—	—	—	—	—	—	—
A. hookeri	—	—	—	—	0·2	0·1	2·4	—	—	—	—	—	—	—
A. regularis	—	—	—	—	0·9	0·1	0·3	—	—	—	—	—	—	—
Thalassiosira antarctica	—	—	—	—	—	—	—	—	—	—	—	—	—	6·0
Dactyliosolen laevis	—	—	—	198·0	1·6	0·8	0·3	0·3	—	—	—	—	—	—
Corethron valdiviae	0·1	—	—	**216·0**	**16·7**	**1·9**	**37·2**	**33·3**	**267·0**	**291·0**	**167·0**	**48·3**	**88·5**	**1,576·5**
Rhizosolenia alata	—	—	—	48·0	1·9	1·0	—	0·3	—	—	1·0	0·3	0·3	—
Rh. curva	—	—	—	—	—	—	—	0·15	—	—	—	—	—	—
Rh. obtusa	—	—	—	108·0	1·1	4·6	—	—	—	—	—	—	—	—
Rh. styliformis	—	—	—	**6,282·0**	**30·6**	**22·5**	**2,534·4**	0·3	—	—	2·0	0·6	—	—
Chaetoceros atlanticus	—	—	—	**6,050·0**	—	—	—	—	—	—	—	—	—	—
Ch. criophilum	—	—	—	**3,864·0**	**0·8**	—	**10·8**	**16·95**	**51·0**	**69·0**	**34·0**	—	**12·9**	**22·5**
Ch. curvatus	—	—	—	—	—	—	—	0·9	—	—	—	—	0·3	—
Ch. dichaeta	—	—	—	288·0 30·0t	4·7t	360·0t	—	0·6	—	—	—	—	—	—
Ch. socialis	—	—	—	—	0·5	0·6	—	**927·75**	**125,760·0**	**502,200·0**	**530,880·0**	**6,056·4**	**4,527·6**	**16,653·0**
Ch. schimperianus	—	—	—	36·0	—	0·6	0·6	—	—	—	—	—	—	—
Biddulphia striata	—	—	—	—	—	—	—	0·3	—	—	2·0	—	—	—
Eucampia antarctica	—	—	—	36·0b 1·2m	0·2b	—	—	—	—	—	20·0b	—	—	—
Fragillaria antarctica	0·6	—	—	**1,176·0**	**93·0**	**0·6**	**7·5**	**1·05**	—	—	**74·0**	—	—	—
Thalassiothrix antarctica	—	—	29·2	—	—	—	—	**1·0**	**7·6**	**5·2**	**12·0**	—	**10·8**	—
Pleurosigma directum	—	—	—	6·0	—	—	—	0·15	—	—	—	—	—	—
Nitzschia seriata	1·6	—	—	**26,160·0**	**1,404·0**	**912·0**	—	—	**27·0**	—	**5·0**	—	—	—
Peridinium spp.	—	—	1·5	18·0	0·6	0·1	0·3	1·2	3·0	—	1·0	—	0·3	—
Ceratium pentagonum	—	—	—	—	2·8l 0·6g	—	—	—	—	—	—	—	—	—
Distephanus speculum	—	—	—	108·0	—	—	0·6	0·75	—	—	—	—	0·3	—
Total of all species (i.e. not only those given in table but also those given in text)	2·5	0·2	33·4	45,610·0	1,476·4	1,305·9	2,614·2	986·5	126,127·6	502,574·2	531,206·0	6,107·4	4,643·1	18,262·5
Volume of phytoplankton in cc.	0·5	0·5	6·5	165·0	3·75	2·0	3·25	0·5	10·0	56·0	132·0	5·0	3·0	28·0

b = var. *balaustium*. g = var. *grandis*. l = var. *longisetum*. m = *mölleria*. t = *tenuicornis*, Mangin.

Phytoplankton Tables (*cont.*)

Grouping of stations	Phytoplankton Group 3														—	—
Station	**WS 27**	**WS 28**	**WS 29**	**126**	**127**	**128**	**129**	**124**	**125**	**131**	**132**	**WS 39**	**135**	**136**	**WS 61**	**151**
Fraction of sample examined	1/300	1/300	1/200 + 1/10	1/300	1/300	1/300	1/300	1/3000	1/1500	1/1500	1/1500	1/100	1/300	1/300	1/100	1/100
Coscinodiscus bouvet	—	—	—	—	—	0·3	2·7	—	1·5	—	1·5	0·2	—	1·2	—	0·1
C. curvatulus	5·1	0·9	—	4·5	1·2	0·9	—	—	—	—	—	—	—	0·6	—	—
C. kerguelenensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C. lineatus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C. occuloides	5·1	0·3	0·22	0·6	—	—	0·9	—	—	—	—	—	—	—	—	—
C. oppositus?	—	—	0·22	1·5	0·3	1·5	0·3	—	1·5	—	—	0·1	0·6	1·2	0·2	—
C. sub-bulliens	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Asteromphalus brookei	—	—	—	—	—	—	—	—	1·5	—	—	0·1	—	—	—	—
A. hookeri	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
A. regularis	—	—	—	—	—	0·3	—	—	—	1·5	—	—	—	—	—	0·1
Thalassiosira antarctica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·4
Dactyliosolen laevis	—	—	—	—	—	0·3	—	—	—	—	—	—	—	0·6	—	—
Corethron valdiviae	**346·8**	**542·0**	**138·16**	**75·9**	**175·8**	**225·6**	**384·6**	**10,866·0**	**1,221·5**	**3,216·0**	**1,003·5**	**4·6**	**94·8**	**252·3**	**17·7**	**5·6**
Rhizosolenia alata	—	—	—	—	—	—	0·3	—	—	—	—	—	—	—	—	—
Rh. curva	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rh. obtusa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rh. styliformis	—	—	0·22	—	—	—	2·7	—	—	—	1·5	0·2	—	—	0·4	709·8
Chaetoceros atlanticus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ch. criophilum	**0·9**	**6·9**	—	**0·9**	**9·0**	**12·9**	**41·7**	**191·0**	**87·0**	**109·5**	**109·5**	**3·5**	**27·0**	**18·9**	**10·2**	**81·6**
Ch. curvatus	—	—	—	—	—	—	—	—	—	1·5	—	—	—	—	—	—
Ch. dichaeta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ch. socialis	—	—	—	—	—	—	—	—	—	—	—	—	—	0·9	—	—
Ch. schimperianus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**409·5**	—
Biddulphia striata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Eucampia antarctica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fragilaria antarctica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1·9
Thalassiothrix antarctica	—	—	—	—	—	—	—	—	3·0	—	—	3·5	—	—	0·5	—
Pleurosigma directum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nitzschia seriata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**18·3**	—
Peridinium spp.	—	—	—	—	0·3	—	—	—	—	—	—	—	—	—	—	—
Ceratium pentagonum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Distephanus speculum	—	—	—	—	—	—	—	—	—	—	—	—	—	0·3	0·1	—
Total of all species (i.e. not only those given in table but also those given in text)	358·2	550·1	138·82	84·3	186·9	241·5	430·5	11,057·0	1,317·5	3,328·5	1,116·0	9·3	122·4	276·3	457·8	799·6
Volume of phytoplankton in cc.	6·0	11·0	5·0	5·5	5·0	6·5	10·5	69·0	22·0	33·0	20·0	1·5	4·0	7·0	2·0	2·5

Phytoplankton Tables (*cont.*)

Grouping of stations	Phytoplankton Group 4														
Station	**WS 51**	**WS 45**	**WS 43**	**WS 44**	**WS 40**	**WS 31**	**WS 33**	**WS 34**	**WS 35**	**WS 36**	**WS 37**	**137**	**138**	**WS 38**	**133**
Fraction of sample examined	1/300	1/2400	1/6000	1/6000	1/6000	1/1800	1/200	1/1000	1/1500	1/300	1/200	1/600	1/100	1/200	1/600
Coscinodiscus bouvet	—	—	—	12·0	6·0	12·6	0·4	8·0	16·5	4·8	0·4	28·2	1·1	0·4	8·4
C. curvatulus	—	2·4	6·0	12·0	—	5·4	—	—	—	—	—	—	—	—	—
C. kerguelenensis	2·4	7·2	18·0	6·0	6·0	—	1·0	—	22·5	7·5	—	—	—	0·4	—
C. lineatus	—	2·4	—	—	48·0	—	—	—	—	—	—	—	—	0·4	—
C. occuloides	—	—	—	—	—	—	0·8	—	—	—	—	2·4	0·2	—	—
C. oppositus?	12·6	40·8	18·0	42·0	36·0	9·0	2·8	5·0	225·0	52·5	0·6	12·0	0·8	4·4	20·4
C. sub-bulliens	0·6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Asteromphalus brookei	—	4·8	6·0	—	—	—	—	1·0	1·5	0·3	0·2	—	—	—	0·6
A. hookeri	—	4·8	—	1·8	—	—	0·2	—	—	—	—	—	—	—	—
A. regularis	—	4·8	6·0	—	6·0	1·8	0·2	1·0	—	0·6	0·2	0·6	—	0·2	2·4
Thalassiosira antarctica	—	—	30·0	—	—	16·2	—	13·0	79·5	—	4·2	19·2	0·6	15·4	—
Dactyliosolen laevis	0·3	4·8	24·0	48·0	42·0	1·8	0·2	5·0	45·0	2·4	—	1·8	—	—	1·2
Corethron valdiviae	**30·0**	**561·6**	**504·0**	**186·0**	**138·0**	**41·4**	**35·8**	**61·0**	280·5	**30·0**	**327·0**	**27·6**	**0·6**	**2·4**	**36·6**
Rhizosolenia alata	0·6	4·8	6·0	12·0	—	—	0·4	1·0	1·5	1·5	0·2	0·6	—	0·4	2·4
Rh. curva	—	—	—	—	—	—	—	1·0	—	—	—	1·2	—	—	—
Rh. obtusa	—	2·4	18·0	—	24·0	—	0·2	—	—	1·2	—	1·2	—	—	1·2
Rh. styliformis	1·2	7·2	12·0	24·0	24·0	3·6	0·6	6·0	4·5	0·9	0·8	4·2	—	1·0	9·0
Chaetoceros atlanticus	1·2	—	156·0	138·0	—	—	—	—	—	—	—	4·2	—	—	—
Ch. criophilum	**2·4**	**62·0**	**156·0**	—	**12·0**	**28·8**	**47·0**	**43·0**	777·5	**2·4**	**37·0**	**42·0**	**2·2**	**6·0**	**97·2**
Ch. curvatus	—	40·8	6·0	72·0	84·0	—	—	—	—	—	—	—	—	1·8	4·2
Ch. dichaeta	1·5t	7·2	—	12·0 36·0t	42·0 6·0t	—	—	—	—	0·6	—	—	—	0·6t	10·2t
Ch. socialis	**168·0**	**64,800·0**	**57,120·0**	**49,000·0**	**89,000·0**	**97,000·0**	**230·4**	**20,800·0**	**5,760·0**	**172·3**	**1·2**	**1,176·0**	—	**94·4**	**48·6**
Ch. schimperianus	—	31·2	54·0	132·0	102·0	—	0·6	—	75·0	3·6	—	2·4	—	3·2	1·2
Biddulphia striata	—	45·6	72·0	—	—	23·4	0·6	5·0	57·0	1·2	—	27·0	—	0·8	3·0
Eucampia antarctica	**0·3b**	**88·8b**	**48·0b**	**18·0b** **30·0m**	**42·0b** **62·0m**	**46·8b**	—	**9·0b**	**25·5b** **6·0m**	**0·6b**	—	**6·6b** **1·2m**	**0·1b**	**0·8b**	**3·0b**
Fragilaria antarctica	**2·1**	**405·6**	**876·0**	**3,360·0**	**4,140·0**	**32·4**	**13·4**	**81·0**	**30·0**	**36·9**	—	**10·4**	—	**5·4**	—
Thalassiothrix antarctica	6·5	131·0	73·8	74·2	62·6	—	—	16·8	20·6	20·2	4·6	18·2	1·2	0·6	9·6
Pleurosigma directum	0·3	9·6	30·0	54·0	42·0	1·8	0·2	4·0	7·5	—	0·2	—	—	—	—
Nitzschia seriata	**307·2**	**32,400·0**	**24,192·0**	**61,200·0**	**63,180·0**	—	**2·6**	**141·0**	**729·0**	**252·1**	—	**371·8**	—	**25·4**	**48·0**
Peridinium spp.	0·3	36·0	18·0	30·0	90·0	5·4	1·2	8·0	4·5	1·2	0·2	1·8	0·3	—	1·2
Ceratium pentagonum	—	—	6·0l	6·0l	—	—	0·2l	—	—	—	—	—	0·1l	—	0·6l
Distephanus speculum	0·3	57·6	12·0	60·0	54·0	43·2	1·2	1·7	52·5	0·3	0·4	5·4	—	1·4	1·2
Total of all species (i.e. not only those given in table but also those given in text)	582·4	99,051·6	101,679·8	143,824·2	193,358·6	97,232·2	341·2	21,264·8	8,259·1	608·7	378·4	1,799·6	6·7	166·3	322·8
Volume of phytoplankton in cc.	2·0	17·0	21·0	11·0	7·5	15·0	3·5	13·5	15·0	4·25	10·0	7·0	1·0	1·5	10·0

b = var. *balaustium*. l = var. *longisetum*. m = var. *mölleria*. t = var. *tenuicornis*, Mangin.

Phytoplankton Tables (*cont.*)

Grouping of stations	Phytoplankton Group 5. Coastal Water				Sub-Antarctic Zone			South Georgia, May, 1927					
Station	**130**	**134**	**WS 41**	**WS 42**	**WS 68**	**WS 69**	**WS 70**	**WS 110**	**WS 111**	**WS 112**	**WS 113**	**WS 114**	Total all stations
Fraction of sample examined	1/300	1/300	1/60	1/600	1/200	1/200	1/150	1/100	1/300	1/100	1/100	1/100	—
Coscinodiscus bouvet	0·3	—	—	—	—	—	—	0·4	—	—	—	—	114,000
C. curvatulus	—	—	—	—	—	—	—	—	—	—	0·1	—	40,300
C. kerguelenensis	—	—	—	—	—	—	—	—	0·3	—	0·1	—	52,900
C. lineatus	—	—	—	—	—	—	—	0·2	—	0·2	—	0·2	55,150
C. occuloides	1·2	—	—	—	—	—	—	—	—	—	—	—	17,020
C. oppositus?	—	3·3	—	—	—	—	—	1·0	0·3	0·2	0·3	0·3	517,020
C. sub-bulliens	—	—	—	—	—	—	—	1·4	—	3·4	0·1	2·0	20,600
Asteromphalus brookei	—	—	—	—	—	—	—	—	—	—	—	—	59,200
A. hookeri	—	—	—	—	0·8	—	—	0·1	0·3	—	0·1	—	60,200
A. regularis	—	—	—	—	—	—	—	—	—	—	—	0·1	70,300
Thalassiosira antarctica	—	—	—	—	—	—	—	—	—	—	—	—	184,500
Dactyliosolen laevis	—	—	—	—	3·2	—	—	—	—	—	—	—	381,600
Corethron valdiviae	4·2	0·6	1·8	4·2	10·2	8·8	—	18·6	9·0	9·0	14·1	3·0	23,839,560
Rhizosolenia alata	—	—	0·06	0·6	1·0	1·8	—	0·2	0·3	0·2	0·4	—	89,060
Rh. curva	—	—	—	—	27·8	136·0	1·2	0·1	—	0·3	0·4	—	168,150
Rh. obtusa	—	—	—	—	—	—	—	0·1	—	—	—	—	171,900
Rh. styliformis	—	—	—	1·2	2·4	107·6	3·0	1·2	2·4	0·6	1·3	0·3	9,806,220
Chaetoceros atlanticus	—	—	—	—	—	—	—	1·0	21·6	2·5	3·3	1·4	6,379,200
Ch. criophilum	—	0·6	—	3·0	0·4	—	—	5·3	51·0	—	1·3	1·3	6,160,050
Ch. curvatus	—	—	—	—	0·2	—	—	—	1·5	0·1	0·8	—	214,100
Ch. dichaeta	—	—	—	—	2·2t	—	—	—	3·0l	—	—	—	444,600
Ch. socialis	—	—	—	—	0·2	—	—	0·9	3·0	—	21·5	4·8	1,492,817,150
Ch. schimperianus	—	—	—	—	—	—	—	—	—	—	—	—	442,400
Biddulphia striata	—	—	—	—	—	—	—	—	—	—	—	—	237,900
Eucampia antarctica	—	—	—	1·2b	—	—	—	0·1b	—	—	—	0·4b	447,800
Fragilaria antarctica	—	—	1·86	4·8	2·8	—	—	1·4	—	1·1	1·7	0·5	10,362,010
Thalassiothrix antarctica	—	—	0·8	3·2	—	—	—	1·2	—	—	—	—	517,900
Pleurosigma directum	—	—	—	—	—	—	—	—	—	—	—	—	155,750
Nitzschia seriata	—	—	—	—	—	—	—	2·6	0·3	—	13·4	1·5	211,394,800
Peridinium spp.	—	—	0·12	4·2	0·2	1·0	—	0·9	0·3	0·3	0·1	0·7	232,200
Ceratium pentagonum	—	—	—	1·2l	1·0l 0·8g 0·6i	0·2l 9·6g	1·0l 3·3g 0·6i	0·2l	—	0·5l	1·2l	0·2l	35,800
Distephanus speculum	—	—	0·06	0·6	—	—	—	—	—	0·1	—	—	417,850
Total of all species (i.e. not only those given in table but also those given in text)	5·7	4·8	3·44	24·2	61·0	264·0	9·6	101·5	48·0	54·9	64·2	45·4	1,930,987,760 (Grand total all species)
Volume of phytoplankton in cc.	0·5	0·5	0·5	0·5	6·5	7·0	2·0	2·0	3·0	1·5	2·0	2·0	

b = var. *balaustium*. g = var. *grandis*. i = intermediate form. l = var. *longisetum*. t = var. *tenuicornis*, Mangin.

APPENDIX II

ZOOPLANKTON TABLES

Table I

Analyses of zooplankton samples collected in the closing N 70 V nets. Only the more important species are shown, the details of occurrence of the less important species being given in the text. The numbers shown represent the *numbers or estimated numbers per sample* and not the number per 50 m. haul, which is the figure more frequently used in the charts and tables in the text. The hour figures for stations taken between sunset and sunrise are shown in heavy type. Full details of the meteorological and hydrological conditions will be found in the Station List, *Discovery Reports*, I, pp. 1–140.

Details of the sex ratios of the Copepoda, where determined, are not included in the Table; but students wishing to examine the data may have access to the original analysis sheets upon application to the Discovery Committee.

Zooplankton Table I. *See foregoing explanation on p. 377.*

Station	9			10				11			
Date	11. ii. 26			13. ii. 26				16. ii. 26			
Hour	0730–0800			1430–1550				1000–1300			
Position	46° 11′ 30″ S, 22° 27′ 30″ W			46° 35′ S, 24° 15′ 30″ W				50° 26′ S, 30° 27′ W			
Sounding (m.)	4090			4402				5000			
Depth of nets (m.) ...	50–0	100–50	250–100	50–0	100–50	250–100	500–250	50–0	100–50	250–100	500–250
Foraminifera	—	—	—	30	40	—	1	15	—	—	—
Radiolaria	—	—	160	—	13	—	1	15	—	40	80
Medusae	—	—	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	38	71	—	23	25	—	50	28	18	40
Sagitta maxima	—	—	5	—	—	—	—	—	—	—	1
S. planktonis	—	—	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	2	—	—	5	—	—	3	—	—
Chaetognatha, *alia*	—	140	609	—	26	150	14	—	—	20	—
Pelagobia longicirrata	—	—	—	—	—	—	—	—	—	—	—
Polychaeta juv.	—	—	—	—	—	—	—	—	—	3	40
Conchoecia hettacra	—	—	—	—	—	—	—	—	—	—	—
Ostracoda juv.	—	260	300	—	—	50	6	—	39	60	80
Calanus simillimus	—	—	—	—	—	—	—	4	—	—	8
C. propinquus	560	6542	4367	720	246	50	23	19,120	2525	610	100
C. acutus	2	—	3	—	—	—	—	120	151	210	160
Rhincalanus gigas	1	16	16	—	—	—	—	—	75	1,280	200
Clausocalanus laticeps	—	—	—	—	—	—	—	—	—	—	—
Ctenocalanus vanus	6	78	120	196	431	49	60	167	1123	32	2500
Microcalanus pygmaeus	—	—	—	2	3	—	—	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	—	15	32	—	—	—	—	—	14	34	61
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	12	—	—	—	—	58	211	2,721	66
Pleuromamma robusta	—	—	—	—	—	—	—	—	—	—	1
Metridia gerlachei	—	—	—	—	—	—	—	—	—	1	—
M. lucens	1	78	88	—	—	1	—	—	422	3,191	990
Oithona frigida	4800	3720	2400	5550	1827	2550	60	1,440	3655	11,620	5200
Parathemisto gaudichaudi	—	36	62	30	—	—	—	2	—	—	—
Primno macropa	—	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	1	—	—	—	—
Amphipoda, *alia*	—	—	—	—	13	—	—	—	146	37	—
Mysidae	—	—	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—	—	4
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	1
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	—	2	8	1	—
Thysanoessa sp. ♀	—	—	—	—	—	—	—	2	8	3	—
Thysanoessa, cyrtopia	—	—	—	—	—	—	—	5	21	6	4
Thysanoessa, furcilia	—	—	—	—	—	—	—	—	—	21	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	64	2	—
L. helicina	—	—	—	—	—	—	—	—	—	—	—
Limacina juv.	100	120	180	50	147	—	5	300	75	40	—
Salpa fusiformis	—	—	—	—	—	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—	—	20	—

Zooplankton Table I (*cont.*)

Station	12				13			14		
Date	18. ii. 26				3. iii. 26			3. iii. 26		
Hour	1415–1615				0930–0950			1250–1315		
Position	51° 55′ S, 32° 27′ 30″ W				5·7 miles N 49½° E of Jason Lt, S. Georgia			15·4 miles N 44½° E of Jason Lt, S. Georgia		
Sounding (m.)	2744				143			260		
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	50–0	100–50	135–100	50–0	100–50	250–100
Foraminifera	—	—	60	40	—	—	—	1	—	—
Radiolaria	—	—	—	200	—	—	—	—	—	—
Medusae	—	—	—	—	—	—	1	—	—	—
Beroë	—	—	—	—	—	—	—	—	—	2
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	2	—	26	24	—	—	12	—	—	98
Sagitta maxima	—	—	—	3	—	—	1	—	—	1
S. planktonis	—	—	—	3	—	—	—	—	—	—
S. gazellae	—	—	—	2	—	—	—	—	—	3
Chaetognatha, *alia*	—	40	—	80	—	—	—	—	—	180
Pelagobia longicirrata	—	—	—	—	—	—	—	—	—	—
Polychaeta juv.	—	—	60	55	—	—	40	2	—	300
Conchoecia hettacra	—	—	—	—	—	—	—	—	—	—
Ostracoda juv.	—	—	30	15	—	—	—	—	—	—
Calanus simillimus	—	—	72	—	—	—	6	—	—	—
C. propinquus	500	850	170	72	12	248	120	23	500	600
C. acutus	45	244	290	56	24	176	232	3	60	2,700
Rhincalanus gigas	41	116	50	12	6	20	33	3	20	180
Clausocalanus laticeps	—	—	—	—	—	—	—	—	—	—
Ctenocalanus vanus	104	1330	3,749	960	106	2438	1462	40	1860	5,100
Microcalanus pygmaeus	—	—	1	—	6	6	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	—	—	72	7	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	73	217	18	—	—	18	—	—	1,620
Pleuromamma robusta	—	—	—	18	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	—	—
M. lucens	10	—	1,448	542	—	6	—	—	—	2,160
Oithona frigida	3350	8900	15,270	2080	762	6250	4080	176	1480	15,060
Parathemisto gaudichaudi	—	—	18	2	—	—	2	—	3	6
Primno macropa	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	1	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—	14
E. frigida, furcilia	—	—	—	—	—	—	—	—	—	2
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	1	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—
T. vicina ♂	1	22	—	—	3	2	3	—	2	1
Thysanoessa sp. ♀	—	2	1	—	1	2	4	—	2	7
Thysanoessa, cyrtopia	12	2	—	2	7	6	2	2	19	16
Thysanoessa, furcilia	—	1	—	—	—	—	—	—	1	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—	—
Limacina juv.	—	40	30	—	8	—	40	—	—	60
Salpa fusiformis	—	—	—	1	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**15**			**16**				
Date	3. iii. 26			3. iii. 26				
Hour	1605–1630			**1905–2045**				
Position	25 miles N 45½° E of Jason Lt, S. Georgia			36·5 miles N 46° E of Jason Lt, S. Georgia				
Sounding (m.)	191			727				
Depth of nets (m.) ...	50–0	100–50	190–100	50–0	100–50	250–100	500–250	700–500
Foraminifera	—	—	—	—	—	—	1	Sample missing
Radiolaria	—	—	—	—	—	—	1	
Medusae	—	—	—	—	—	—	—	
Beroë	—	—	—	—	—	—	—	
Ctenophora, *alia*	—	—	—	—	—	—	—	
Eukrohnia hamata	—	15	10	—	3	40	—	
Sagitta maxima	—	—	—	—	—	2	—	
S. planktonis	—	—	—	—	—	—	—	
S. gazellae	—	—	—	—	—	1	—	
Chaetognatha, *alia*	—	—	40	4	—	—	2	
Pelagobia longicirrata	—	—	—	—	—	—	—	
Polychaeta juv.	15	—	40	—	—	40	—	
Conchoecia hettacra	—	—	—	—	—	—	—	
Ostracoda juv.	—	—	—	—	—	—	—	
Calanus simillimus	—	—	—	—	—	—	—	
C. propinquus	37	160	96	300	200	95	17	
C. acutus	1	60	368	16	40	284	1	
Rhincalanus gigas	24	640	304	8	160	316	4	
Clausocalanus laticeps	—	—	—	—	—	—	—	
Ctenocalanus vanus	314	1,880	2760	220	675	1,960	54	
Microcalanus pygmaeus	—	—	—	—	—	—	—	
Drepanopus pectinatus	—	—	—	—	—	—	—	
Pareuchaeta antarctica	—	—	—	—	13	120	—	
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	
Scolecithricella minor	—	—	18	—	—	—	—	
Pleuromamma robusta	—	—	—	—	—	—	—	
Metridia gerlachei	—	—	—	—	—	—	—	
M. lucens	4	—	902	4	405	890	4	
Oithona frigida	1320	19,200	3400	1570	7080	22,400	186	
Parathemisto gaudichaudi	1	26	48	1	3	16	—	
Primno macropa	—	—	—	—	—	—	—	
Vibilia antarctica	—	—	—	—	—	—	—	
Cyllopus sp.	—	—	—	—	—	—	—	
Amphipoda, *alia*	—	—	—	—	—	—	—	
Mysidae	—	—	—	—	—	—	—	
Euphausia frigida, adult	—	—	—	—	—	11	—	
E. frigida, cyrtopia	—	—	2	—	—	37	—	
E. frigida, furcilia	—	—	—	—	—	2	—	
E. frigida, calyptopis	—	—	—	—	—	—	—	
E. superba, adult	—	—	—	—	—	—	—	
E. superba, cyrtopia	—	—	—	—	—	—	—	
E. superba, furcilia	—	—	—	—	—	1	—	
E. superba, calyptopis	—	—	—	—	—	—	—	
Thysanoessa macrura ♂	—	—	—	—	—	—	—	
T. vicina ♂	2	—	—	—	—	—	—	
Thysanoessa sp. ♀	1	—	1	1	—	3	—	
Thysanoessa, cyrtopia	43	—	6	—	—	—	—	
Thysanoessa, furcilia	—	6	—	—	—	—	—	
Thysanoessa, calyptopis	—	—	—	—	—	—	—	
Limacina balea	—	—	—	—	—	—	—	
L. helicina	—	—	—	—	—	—	—	
Limacina juv.	—	—	—	8	80	—	—	
Salpa fusiformis	—	—	—	—	—	—	—	
Appendicularia	—	—	—	—	—	—	—	

Zooplankton Table I (*cont.*)

Station	**17**					**18**			**19**		
Date	4. iii. 26					4. iii. 26			4. iii. 26		
Hour	**0000–0235**					1105–1155			1340–1420		
Position	46 miles N 46° E of Jason Lt, S. Georgia					4·8 miles N 34° E of C. Saunders, S. Georgia			10 miles N 39° E of C. Saunders, S. Georgia		
Sounding (m.)	1950					140			200		
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	50–0	100–50	135–100	50–0	100–50	190–100
Foraminifera	—	—	—	—	—	—	—	—	—	—	—
Radiolaria	—	—	—	3	—	—	—	60	—	—	—
Medusae	—	—	—	1	—	—	—	—	—	—	—
Beroë	—	—	3	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	2	—	—	—	—	—	—	—
Eukrohnia hamata	—	4	34	29	—	1	12	13	—	—	8
Sagitta maxima	—	—	—	8	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—	—	—
S. gazellae	—	1	1	1	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	20	—	—	—	—	—	—	—	—	—
Pelagobia longicirrata	—	—	—	—	—	—	—	—	—	—	—
Polychaeta juv.	—	20	—	90	—	—	—	180	—	—	—
Conchoecia hettacra	—	—	—	—	—	—	—	—	—	—	—
Ostracoda juv.	2	—	50	10	—	—	—	—	—	—	—
Calanus simillimus	6	58	1	—	—	—	78	83	—	—	—
C. propinquus	670	160	226	180	—	20	39	28	9	252	360
C. acutus	40	60	50	360	—	11	846	565	3	72	720
Rhincalanus gigas	—	240	200	90	—	—	59	234	3	1	385
Clausocalanus laticeps	—	—	—	—	—	—	—	28	—	—	—
Ctenocalanus vanus	4376	1170	625	2614	5	10	3000	2760	586	150	600
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	38	59	16	30	1	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	2052	85	—	—	—	—	14	—	—	—
Pleuromamma robusta	—	132	6	20	—	—	—	—	—	—	—
Metridia gerlachei	—	15	5	—	—	—	—	—	—	—	—
M. lucens	220	294	266	163	—	25	—	—	—	—	—
Oithona frigida	2640	8640	950	1380	15	—	9760	—	720	2525	13,800
Parathemisto gaudichaudi	1	—	—	—	—	—	2	—	1	2	1
Primno macropa	—	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	31	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	2	—	—	—	2	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	1	13	—	1	—	—	—	—	—	—	—
E. frigida, cyrtopia	25	29	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	2	2	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	10	—	—	—	—	—	—	—	—	—	—
E. superba, adult	2	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	6	1	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—	—
T. vicina ♂	12	5	1	—	—	2	—	2	15	7	2
Thysanoessa sp. ♀	24	1	3	4	—	3	12	1	16	7	—
Thysanoessa, cyrtopia	50	43	6	—	—	31	19	3	53	40	15
Thysanoessa, furcilia	9	9	—	—	—	—	1	—	8	—	—
Thysanoessa, calyptopis	7	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	30	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—	—	—
Limacina juv.	2	20	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	4	—	—	—	—	—	—	—
Appendicularia	—	—	—	3	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**20**			**21**			**23**		
Date	4. iii. 26			4. iii. 26			14. iii. 26		
Hour	1530–1650			1750–1900			1215–1255		
Position	14·6 miles N 41° E of C. Saunders, S. Georgia			20·5 miles N 44° E of C. Saunders, S. Georgia			5·3 miles N 44° E of Merton Rock, S. Georgia		
Sounding (m.)	210			326			228		
Depth of nets (m.) ...	50–0	100–50	200–100	50–0	100–50	250–100	50–0	100–50	190–100
Foraminifera	—	—	—	—	—	—	—	—	—
Radiolaria	—	—	—	—	5	40	—	—	—
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	4	1	—	—	—	1	12
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Pelagobia longicirrata	—	—	—	—	—	—	—	—	10
Polychaeta juv.	8	—	—	—	—	40	—	—	240
Conchoecia hettacra	—	—	—	—	—	—	—	—	—
Ostracoda juv.	—	—	—	—	—	2	—	—	1
Calanus simillimus	2	—	—	4	—	—	—	1	2
C. propinquus	50	312	200	70	32	384	8	99	115
C. acutus	40	44	220	40	1	50	7	67	302
Rhincalanus gigas	20	44	260	31	1	248	—	43	289
Clausocalanus laticeps	—	—	—	—	—	—	—	—	—
Ctenocalanus vanus	75	384	1840	40	95	1,560	—	755	1356
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	20	—	—	—	16	—	—	14
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	196
M. lucens	—	—	—	—	8	814	—	—	5
Oithona frigida	80	1840	6240	640	298	13,480	—	1582	6011
Parathemisto gaudichaudi	13	12	34	6	—	68	2	6	48
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	850	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	7	—	—	2
E. frigida, cyrtopia	—	—	—	—	—	7	—	—	4
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	1	—
T. vicina ♂	4	2	—	—	—	—	3	5	3
Thysanoessa sp. ♀	4	4	—	—	—	—	2	7	4
Thysanoessa, cyrtopia	22	8	7	24	—	1	25	10	3
Thysanoessa, furcilia	1	—	—	—	—	—	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	3
L. helicina	—	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	—	—	—	—	—	1
Salpa fusiformis	—	—	—	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**30**			**31**			**41** A			
Date	16. iii. 26			17. iii. 26			28. iii. 26			
Hour	1500–1600			1755–**1845**			1300–1345			
Position	W. Cumberland Bay S. Georgia, 2·8 miles S 24° W of Jason Lt			13·5 miles N 89° E of Jason Lt, S. Georgia			16½ miles N 39° E of Barff Pt, S. Georgia (ship anchored by stern with kedge)			
Sounding (m.)	251			220			272			
Depth of nets (m.) ...	50–0	100–50	230–100	50–0	100–50	220–100	50–0	100–50	150–100	265–150
Foraminifera	—	—	—	—	—	—	—	—	—	—
Radiolaria	—	—	—	—	—	—	—	—	—	—
Medusae	—	—	1	—	—	—	—	—	—	—
Beroë	—	—	10	1	—	—	—	—	—	—
Ctenophora, *alia*	—	1	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	6	28	—	33	41	—	—	10	47
Sagitta maxima	—	—	1	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	1	—	2	1	—	—	—	2
Chaetognatha, *alia*	—	60	—	—	—	—	—	—	—	—
Pelagobia longicirrata	—	—	—	—	—	—	—	—	—	—
Polychaeta juv.	40	61	—	—	—	360	—	—	—	8
Conchoecia hettacra	—	—	—	—	—	—	—	—	—	—
Ostracoda juv.	—	—	—	—	—	—	—	—	—	—
Calanus simillimus	1	2	192	1	59	57	—	—	16	—
C. propinquus	19	447	1,531	44	33	955	1	109	89	450
C. acutus	270	561	3,456	10	144	1,266	—	45	29	1,620
Rhincalanus gigas	13	36	345	—	16	394	—	9	135	122
Clausocalanus laticeps	—	—	—	—	—	—	—	—	—	—
Ctenocalanus vanus	4015	1092	10,450	14	492	8,523	—	127	1350	5,604
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	29	5724	77,452	—	—	1,412	—	—	80	3,652
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—	30
Pareuchaeta sp. juv.	—	—	63	—	—	—	—	—	—	—
Scolecithricella minor	15	—	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	43	—	—	—	—	—	—	—	1
M. lucens	—	—	1	—	—	171	—	—	270	2,740
Oithona frigida	6804	3906	12,756	—	2023	13,497	—	1200	6150	21,420
Parathemisto gaudichaudi	—	1	—	6	15	19	—	2	11	10
Primno macropa	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	1	—	—	—	—	—	—	—
Mysidae	—	4	16	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	1	—	—	—	—	—	—	9
E. frigida, cyrtopia	—	—	1	—	—	7	—	—	—	4
E. frigida, furcilia	—	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	1	—	—	—	—	—	—	—
T. vicina ♂	1	4	8	15	6	2	1	3	1	5
Thysanoessa sp. ♀	—	3	16	17	9	10	2	4	—	6
Thysanoessa, cyrtopia	13	20	36	23	11	5	10	13	6	12
Thysanoessa, furcilia	1	—	—	—	—	—	2	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	4	—	—	—	—	—	—	5	—
L. helicina	—	—	—	—	—	—	—	—	—	—
Limacina juv.	40	—	—	—	—	—	—	—	—	10
Salpa fusiformis	—	—	—	—	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	41 B				41 C			
Date	28. iii. 26				28. iii. 26			
Hour	1540–1605				1700–1728			
Position	16½ miles N 39° E of Barff Pt, S. Georgia (ship anchored by stern with kedge)				16½ miles N 39° E of Barff Pt, S. Georgia (ship anchored by stern with kedge)			
Sounding (m.)	272				272			
Depth of nets (m.) ...	50–0	100–50	150–100	265–150	50–0	100–50	150–100	240–150
Foraminifera	—	—	—	—	—	—	—	—
Radiolaria	—	—	—	—	—	—	—	—
Medusae	—	—	1	1	—	—	—	—
Beroë	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	1	—	—	—	—	—	39
Sagitta maxima	—	—	—	—	—	—	—	2
S. planktonis	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	16	—	—	4	—
Pelagobia longicirrata	—	—	—	—	—	—	—	—
Polychaeta juv.	—	—	—	80	—	—	25	—
Conchoecia hettacra	—	—	—	—	—	—	—	—
Ostracoda juv.	—	—	—	—	—	—	—	—
Calanus simillimus	—	2	23	—	1	10	10	—
C. propinquus	7	91	28	416	8	60	69	385
C. acutus	20	17	36	1,120	—	15	70	685
Rhincalanus gigas	1	18	50	5	2	20	73	41
Clausocalanus laticeps	—	—	—	—	—	—	—	—
Ctenocalanus vanus	184	238	1050	600	128	1450	2725	800
Microcalanus pygmaeus	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	—	1	10,360	—	—	—	14,160
Pareuchaeta antarctica	1	—	—	11	—	—	—	6
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	1	—	—	—	—	—
M. lucens	152	12	40	1,000	—	—	150	880
Oithona frigida	70	1150	2250	2,220	16	1200	2800	14,980
Parathemisto gaudichaudi	6	33	86	18	7	30	11	9
Primno macropa	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—
Mysidae	—	—	—	1	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	3	—
E. frigida, cyrtopia	1	—	—	2	—	—	—	2
E. frigida, furcilia	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	1	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	1
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	1
T. vicina ♂	1	—	—	1	1	—	—	—
Thysanoessa sp. ♀	1	—	—	5	—	—	—	6
Thysanoessa, cyrtopia	1	3	—	—	8	—	8	14
Thysanoessa, furcilia	—	—	—	—	4	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—
Limacina balea	1	—	3	—	—	—	4	—
L. helicina	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	40	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**41 D**				**41 E**				**124**		
Date	28. iii. 26				28. iii. 26				18. xii. 26		
Hour	**1910–1955**				**2105–2140**				1600–1650		
Position	16½ miles N 39° E of Barff Pt, S. Georgia (ship anchored by stern with kedge)				16½ miles N 39° E of Barff Pt, S. Georgia (ship anchored by stern with kedge)				53° 45′ 30″ S, 36° 32′ 30″ W		
Sounding (m.)	272				272				220		
Depth of nets (m.) ...	50–0	100–50	150–100	250–150	50–0	100–50	150–100	250–150	50–0	100–50	210–100
Foraminifera	—	—	—	—	—	—	—	—	—	—	—
Radiolaria	—	—	—	—	—	—	—	—	—	120	—
Medusae	—	—	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	4	14	48	—	—	25	4	—	4	42
Sagitta maxima	—	—	—	4	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—	—	1
S. gazellae	—	—	—	—	—	—	—	—	—	—	1
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	1	—	—
Pelagobia longicirrata	—	—	—	—	—	—	—	—	—	—	1
Polychaeta juv.	—	—	50	132	—	30	15	—	—	—	100
Conchoecia hettacra	—	—	—	—	—	—	—	—	—	—	2
Ostracoda juv.	—	—	—	—	—	—	1	123	—	—	—
Calanus simillimus	14	—	—	—	5	—	1	—	3	16	5
C. propinquus	39	204	10	30	145	300	6	71	20	79	55
C. acutus	5	34	36	556	7	30	36	713	10	13	204
Rhincalanus gigas	2	68	82	26	2	30	50	54	4	20	7
Clausocalanus laticeps	—	—	—	—	—	—	—	—	3	—	—
Ctenocalanus vanus	200	1500	313	980	600	—	—	700	12	212	54
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	2550	3000	636	475	7220	—	770	400	26	1	—
Pareuchaeta antarctica	—	—	2	8	—	—	—	17	—	5	26
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	2	—	44	—	—	—	1	—	52
Pleuromamma robusta	—	—	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	—	—	—
M. lucens	150	360	312	2,025	300	—	380	400	—	—	22
Oithona frigida	250	1780	4325	28,380	880	—	3000	7260	640	—	—
Parathemisto gaudichaudi	168	18	2	—	3	9	—	—	1	1	3
Primno macropa	—	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	4	—	—	1	1	—	—	—
Mysidae	—	—	—	4	—	—	—	—	—	—	—
Euphausia frigida, adult	—	4	—	—	—	11	1	—	—	—	—
E. frigida, cyrtopia	—	4	1	—	1	2	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	1	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	1	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	5	—	—	—
T. vicina ♂	2	21	9	—	5	22	15	—	—	1	—
Thysanoessa sp. ♀	1	18	13	9	2	29	21	8	—	—	—
Thysanoessa, cyrtopia	4	37	39	28	11	35	30	31	—	—	—
Thysanoessa, furcilia	—	1	—	—	—	—	—	—	—	3	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Limacina balea	8	5	—	—	—	—	—	3	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—	—	—
Limacina juv.	—	—	25	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**125**						**126**		**127**		
Date	18–19. xii. 26						19. xii. 26		19. xii. 26		
Hour	**2300–0150**						1055–1120		1345–1407		
Position	53° 28′ 30″ S, 36° 20′ 30″ W						53° 58′ 30″ S, 37° 08′ W		53° 48′ 30″ S, 37° 08′ W		
Sounding (m.)	3140						100		157		
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–50	50–0	100–50	150–110
Foraminifera	Sample missing	—	300	240	60	—	—	—	—	—	—
Radiolaria		80	—	10	202	297	204	—	—	50	100
Medusae		—	—	2	—	—	—	—	—	—	—
Beroë		—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*		—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata		2	27	76	55	14	—	28	—	5	57
Sagitta maxima		—	4	4	—	1	—	—	—	—	1
S. planktonis		—	—	1	—	—	—	—	—	—	—
S. gazellae		—	—	1	—	—	—	3	—	—	—
Chaetognatha, *alia*		—	—	—	60	80	—	—	—	—	—
Pelagobia longicirrata		4	—	3	7	15	—	1	—	—	101
Polychaeta juv.		—	—	—	—	—	—	—	—	50	—
Conchoecia hettacra		3	16	60	15	—	—	—	—	—	2
Ostracoda juv.		40	60	60	60	120	—	—	—	—	—
Calanus simillimus		4	—	—	—	—	—	3	1	7	—
C. propinquus		129	15	27	36	6	36	12	1	15	4
C. acutus		27	171	218	83	14	—	43	—	38	6
Rhincalanus gigas		10	96	91	14	—	—	51	—	50	—
Clausocalanus laticeps		13	13	1	—	—	—	—	—	4	—
Ctenocalanus vanus		392	273	786	564	238	—	520	98	297	68
Microcalanus pygmaeus		—	2	1032	1477	—	298	—	—	—	—
Drepanopus pectinatus		10	—	—	—	—	6498	2617	571	430	725
Pareuchaeta antarctica		11	41	10	25	15	—	8	—	3	28
Pareuchaeta sp. juv.		—	—	21	—	—	—	—	—	—	—
Scolecithricella minor		30	120	391	56	6	—	—	—	3	16
Pleuromamma robusta		14	19	—	1	4	—	—	—	—	—
Metridia gerlachei		48	33	83	14	58	12	—	—	—	3
M. lucens		26	25	214	254	19	—	—	—	—	2
Oithona frigida		1320	2053	2092	1208	87	—	—	880	2150	1150
Parathemisto gaudichaudi		—	—	1	—	—	—	—	—	1	—
Primno macropa		—	—	—	—	—	—	—	—	—	—
Vibilia antarctica		—	—	—	—	—	—	—	—	—	—
Cyllopus sp.		—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*		—	—	3	5	1	—	—	—	—	—
Mysidae		—	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult		2	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia		—	—	—	—	—	—	—	—	—	—
E. frigida, furcilia		6	2	—	—	—	—	—	—	1	—
E. frigida, calyptopis		—	—	—	—	—	—	—	—	—	—
E. superba, adult		1	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia		—	—	—	—	—	—	—	—	—	—
E. superba, furcilia		—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis		—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂		2	2	1	—	—	—	—	—	—	—
T. vicina ♂		2	4	1	—	—	—	—	—	—	—
Thysanoessa sp. ♀		—	4	2	—	—	—	—	—	—	—
Thysanoessa, cyrtopia		—	—	—	—	—	—	—	—	—	—
Thysanoessa, furcilia		8	3	—	—	—	—	—	—	1	—
Thysanoessa, calyptopis		—	—	—	—	—	—	—	—	—	—
Limacina balea		—	—	—	—	—	—	—	—	—	—
L. helicina		—	—	1	—	—	—	—	—	—	—
Limacina juv.		—	—	—	—	—	—	—	—	—	—
Salpa fusiformis		—	1	32	4	—	—	—	—	—	—
Appendicularia		—	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	128			129					
Date	19. xii. 26			19. xii. 26					
Hour	1710–1748			2015–2228					
Position	53° 38′ 30″ S, 37° 08′ W			53° 28′ 30″ S, 37° 08′ W					
Sounding (m.)	167			1001					
Depth of nets (m.) ...	50–0	100–50	160–100	50–0	100–50	250–100	500–250	750–500	950–780
Foraminifera	20	24	40	—	120	810	80	400	80
Radiolaria	20	48	80	—	—	30	132	200	290
Medusae	—	—	—	—	—	1	4	1	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	17	—
Eukrohnia hamata	—	—	14	2	3	19	57	12	5
Sagitta maxima	—	—	2	—	—	—	4	1	1
S. planktonis	—	—	—	—	—	—	1	4	2
S. gazellae	—	—	—	—	—	—	1	—	—
Chaetognatha, *alia*	—	—	—	—	—	180	—	—	—
Pelagobia longicirrata	—	—	3	—	1	—	6	10	253
Polychaeta juv.	—	36	120	—	—	150	120	—	—
Conchoecia hettacra	—	—	4	—	2	—	20	5	1
Ostracoda juv.	—	—	—	—	—	30	200	160	—
Calanus simillimus	28	—	1	47	7	5	—	—	—
C. propinquus	20	—	7	73	23	193	36	9	1
C. acutus	5	8	79	16	49	2	121	21	11
Rhincalanus gigas	—	—	57	—	1	21	65	—	—
Clausocalanus laticeps	—	—	14	6	10	—	—	—	—
Ctenocalanus vanus	—	4	138	64	1059	373	360	56	67
Microcalanus pygmaeus	—	—	70	—	—	—	28	14	356
Drepanopus pectinatus	210	—	142	256	—	—	—	—	—
Pareuchaeta antarctica	—	2	15	—	30	53	25	17	3
Pareuchaeta sp. juv.	—	—	8	3	—	—	—	—	15
Scolecithricella minor	—	—	13	1	24	—	1	—	7
Pleuromamma robusta	—	—	—	—	—	—	14	15	5
Metridia gerlachei	—	—	10	—	1	2	17	58	51
M. lucens	—	—	43	1	13	5	445	72	39
Oithona frigida	900	776	15	1280	5820	—	—	—	372
Parathemisto gaudichaudi	12	—	—	—	—	—	—	—	—
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	4	—	—	—	—	—	—	—	—
Cyllopus sp.	1	—	—	1	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	3	—
Mysidae	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	1	—	—	—
E. frigida, furcilia	—	—	—	1	8	7	—	—	—
E. frigida, calyptopis	—	—	—	—	1	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	1	—	—	—
T. vicina ♂	—	—	—	—	—	—	—	—	—
Thysanoessa sp. ♀	—	—	—	1	—	—	1	—	—
Thysanoessa, cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa, furcilia	—	—	2	24	21	2	—	—	—
Thysanoessa, calyptopis	—	—	—	1	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	1	—	1	1	—	—
Limacina juv.	—	—	—	—	—	30	—	—	—
Salpa fusiformis	—	—	—	27	—	2	—	—	—
Appendicularia	—	—	—	—	1	30	—	—	—

Zooplankton Table I (*cont.*)

Station	130		131			132			
Date	20. xii. 26		20. xii. 26			20. xii. 26			
Hour	1033–1045		1325–1420			1700–1750			
Position	54° 06′ S, 36° 23′ W		53° 59′ 30″ S, 36° 11′ W			53° 52′ S, 35° 58′ 30″ W			
Sounding (m.)	122		240			180			
Depth of nets (m.) ...	50–0	115–50	50–0	100–50	230–100	50–0	100–50	170–125	170–0
Foraminifera	40	14	20	—	30	—	—	—	—
Radiolaria	—	—	—	—	90	50	60	60	60
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	2	—	—	—	—	—	1	—
Eukrohnia hamata	2	14	—	2	78	2	13	56	30
Sagitta maxima	—	4	—	—	1	—	—	—	—
S. planktonis	—	—	—	—	2	—	—	—	—
S. gazellae	—	—	—	—	4	—	—	2	—
Chaetognatha, *alia*	—	30	—	—	—	—	—	—	—
Pelagobia longicirrata	—	—	—	—	3	—	—	6	—
Polychaeta juv.	—	60	—	—	—	—	—	—	—
Conchoecia hettacra	—	—	—	—	1	—	—	—	—
Ostracoda juv.	—	—	—	—	—	—	—	—	—
Calanus simillimus	22	129	44	65	40	26	57	5	42
C. propinquus	4	372	33	45	80	22	95	42	49
C. acutus	2	13	2	3	306	4	84	93	59
Rhincalanus gigas	1	52	—	8	764	4	35	163	64
Clausocalanus laticeps	—	—	1	17	—	2	113	8	4
Ctenocalanus vanus	—	65	24	194	257	50	538	1026	1048
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	1568	3880	7	21	—	6	—	13	—
Pareuchaeta antarctica	—	19	—	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	1	3	40	—	4	17	7
Scolecithricella minor	—	—	—	—	32	6	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	1	—	—	—	—	—	—	1	1
M. lucens	—	—	—	4	24	—	—	—	2
Oithona frigida	640	—	288	1998	6150	1500	3180	1200	6720
Parathemisto gaudichaudi	—	1	—	—	2	—	6	—	3
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	1
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	2	—	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	1	4	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba, adult	1	—	7	—	1	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	1	—	—
Thysanoessa sp. ♀	—	—	—	—	1	—	—	—	1
Thysanoessa, cyrtopia	—	—	—	—	—	—	1	—	—
Thysanoessa, furcilia	—	—	—	14	—	10	21	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	1	1	2	2	—	5
Limacina juv.	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	6	—	11
Appendicularia	—	—	—	—	—	—	—	—	60

Zooplankton Table I (*cont.*)

Station	133					134			135		
Date	20–21. xii. 26					21. xii. 26			21. xii. 26		
Hour	2012–2350					1440–1502			1805–1830		
Position	53° 45′ 30″ S, 35° 46′ 30″ W					54° 22′ S, 35° 56′ W			54° 22′ S, 35° 39′ W		
Sounding (m.)	802					176			243		
Depth of nets (m.) ...	50–0	100–50	270–100	500–250	750–500	50–0	100–50	170–100	50–0	100–50	230–100
Foraminifera	660	540	4000	100	250	1	—	120	—	50	—
Radiolaria	60	—	120	—	6	—	—	—	—	—	750
Medusae	—	—	—	—	—	—	—	—	—	—	—
Beroë	—	2	—	—	—	1	—	2	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	20	39	4	1	—	7	9	—	—	15
Sagitta maxima	—	—	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—	—	2
S. gazellae	—	—	—	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	60	—	—	—	—	—	—	—	150
Pelagobia longicirrata	—	—	190	—	—	—	—	—	—	—	14
Polychaeta juv.	—	—	—	—	—	—	—	120	60	—	—
Conchoecia hettacra	—	—	5	1	—	—	—	—	—	—	6
Ostracoda juv.	—	—	—	—	—	—	—	—	—	—	—
Calanus simillimus	34	1	3	2	—	20	2	—	95	—	—
C. propinquus	200	511	39	4	2	4	39	1	11	58	13
C. acutus	14	2,075	99	4	1	—	95	89	2	104	8
Rhincalanus gigas	3	32	93	—	—	1	13	2	—	8	68
Clausocalanus laticeps	34	510	21	2	—	—	—	—	1	12	—
Ctenocalanus vanus	112	412	256	—	1	—	—	—	70	59	408
Microcalanus pygmaeus	—	—	169	—	16	—	—	—	—	1	—
Drepanopus pectinatus	14	—	—	3	65	—	106	87,670	5084	384	8030
Pareuchaeta antarctica	—	—	—	—	1	—	—	—	—	—	—
Pareuchaeta sp. juv.	1	—	16	—	—	—	—	2	—	5	4
Scolecithricella minor	—	—	63	—	—	—	—	—	—	—	113
Pleuromamma robusta	—	—	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	42	3	11	—	—	—	—	2	13
M. lucens	—	—	12	—	18	—	—	—	—	—	—
Oithona frigida	3120	14,100	918	16	10	—	—	840	480	1008	4713
Parathemisto gaudichaudi	—	2	—	1	—	2	2	—	—	7	—
Primno macropa	—	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	1	—	—	1	—	—	—	—	—	2
Mysidae	—	—	—	—	—	—	—	1	1	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	1	—	—	—	—	1	—	—	—	2
E. frigida, furcilia	—	5	5	—	—	—	—	—	—	—	8
E. frigida, calyptopis	—	—	1	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	6	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—	—
T. vicina ♂	—	—	1	—	—	—	—	—	—	—	—
Thysanoessa sp. ♀	1	1	—	—	—	—	—	—	—	—	—
Thysanoessa, cyrtopia	—	—	—	—	—	—	1	—	—	—	—
Thysanoessa, furcilia	11	42	10	—	—	1	—	—	—	3	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—	—	—
L. helicina	3	29	3	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	—	—	—	—	—	—	—	—
Salpa fusiformis	1	—	—	—	—	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**136**			**137**				
Date	21. xii. 26			22. xii. 26				
Hour	**2138–2210**			**0307–0515**				
Position	54° 22′ S, 35° 21′ W			54° 19′ 30″ S, 35° 03′ 30″ W				
Sounding (m.)	246			740				
Depth of nets (m.) ...	50–0	100–50	235–100	50–0	100–50	250–100	500–250	700–500
Foraminifera	4	150	1120	660	1,980	4500	900	660
Radiolaria	120	—	40	120	240	240	661	4
Medusae	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	1	—	—
Ctenophora, *alia*	—	—	1	—	3	—	—	—
Eukrohnia hamata	1	2	23	9	22	34	41	12
Sagitta maxima	—	—	—	—	—	1	—	—
S. planktonis	—	—	1	—	—	—	5	—
S. gazellae	1	—	—	—	3	—	2	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—
Pelagobia longicirrata	—	6	—	—	70	—	8	4
Polychaeta juv.	—	—	120	—	—	250	120	—
Conchoecia hettacra	—	—	—	—	—	6	11	4
Ostracoda juv.	—	—	—	—	—	180	120	120
Calanus simillimus	38	1	—	64	3	—	—	—
C. propinquus	124	38	346	18	239	273	12	12
C. acutus	—	75	13	94	1,165	92	16	7
Rhincalanus gigas	—	1	167	—	20	28	34	—
Clausocalanus laticeps	—	6	—	—	—	—	—	—
Ctenocalanus vanus	1300	194	192	247	2,042	609	5	73
Microcalanus pygmaeus	—	—	—	—	—	—	14	243
Drepanopus pectinatus	—	50	—	—	714	—	1	—
Pareuchaeta antarctica	—	1	—	1	—	7	17	—
Pareuchaeta sp. juv.	—	—	—	—	33	—	—	9
Scolecithricella minor	—	1	45	36	—	133	—	—
Pleuromamma robusta	—	—	—	—	—	2	4	3
Metridia gerlachei	—	3	13	—	2	284	15	16
M. lucens	27	2	578	—	—	306	12	4
Oithona frigida	780	1350	—	—	10,920	—	—	739
Parathemisto gaudichaudi	1	—	—	1	—	—	—	—
Primno macropa	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	1	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	1	1
Mysidae	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	1	—	—	—	—	—	—
E. frigida, cyrtopia	1	—	—	—	3	—	—	—
E. frigida, furcilia	11	3	—	—	24	11	—	—
E. frigida, calyptopis	—	—	—	—	—	1	—	—
E. superba, adult	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—
T. vicina ♂	—	1	—	—	—	—	—	—
Thysanoessa sp. ♀	—	3	2	—	—	—	1	1
Thysanoessa, cyrtopia	—	1	—	—	13	—	—	—
Thysanoessa, furcilia	6	21	—	19	62	16	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—
L. helicina	2	3	—	8	3	5	—	—
Limacina juv.	—	—	—	—	240	—	60	60
Salpa fusiformis	—	19	9	22	4	35	14	—
Appendicularia	—	—	—	—	61	—	—	—

Zooplankton Table I (*cont.*)

Station	**138**							**139**			
Date	22. xii. 26							22–23. xii. 26			
Hour	0800–1050							**2205–2350**			
Position	54° 17′ S, 34° 47′ W							53° 30′ 15″ S, 35° 50′ 45″ W			
Sounding (m.)	2530							3230			
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	2000–1000	50–0	100–50	250–150	250–170
Foraminifera	120	1380	3900	900	500	80	120	352	120	1460	120
Radiolaria	120	120	—	420	16	279	1042	—	—	—	—
Medusae	—	—	—	—	—	1	1	—	1	—	—
Beroë	—	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	27	24	47	2	7	14	—	—	4	13
Sagitta maxima	—	—	1	1	—	1	—	—	—	—	—
S. planktonis	—	—	—	5	1	—	—	—	—	—	—
S. gazellae	—	—	—	2	—	—	—	—	—	2	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—	—	16
Pelagobia longicirrata	—	64	—	—	9	6	65	—	—	—	—
Polychaeta juv.	—	—	420	240	—	—	—	—	—	60	—
Conchoecia hettacra	—	—	—	13	1	1	—	—	1	3	—
Ostracoda juv.	—	—	60	180	180	—	120	16	—	—	—
Calanus simillimus	8	2	—	—	—	—	—	27	—	11	—
C. propinquus	95	115	165	11	41	—	1	36	84	548	627
C. acutus	102	178	96	12	8	11	181	—	—	89	78
Rhincalanus gigas	—	21	—	—	21	—	—	—	—	11	21
Clausocalanus laticeps	—	34	—	—	—	—	—	30	60	1	78
Ctenocalanus vanus	52	1429	280	548	103	86	46	25	379	277	1123
Microcalanus pygmaeus	—	—	—	—	—	—	601	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	—	10	—
Pareuchaeta antarctica	—	7	28	11	27	—	17	1	—	17	24
Pareuchaeta sp. juv.	—	—	—	—	—	2	—	—	—	—	—
Scolecithricella minor	—	24	24	116	—	—	—	—	—	67	—
Pleuromamma robusta	—	—	—	—	47	—	—	—	—	30	47
Metridia gerlachei	—	—	120	115	309	19	19	1	60	177	104
M. lucens	—	4	81	—	1	3	12	1	45	—	130
Oithona frigida	—	4808	—	—	—	—	163	88	—	—	—
Parathemisto gaudichaudi	1	2	1	—	—	—	—	1	1	1	—
Primno macropa	—	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	4	1	—	—	—	1	2	1	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—	20	—
Mysidae	—	—	—	—	—	1	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	1	2	1
E. frigida, cyrtopia	—	—	4	—	—	—	—	3	3	—	—
E. frigida, furcilia	—	—	7	1	3	—	—	2	27	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa sp. ♀	—	—	—	—	—	—	—	—	—	8	5
Thysanoessa, cyrtopia	—	1	1	—	—	—	—	—	—	—	—
Thysanoessa, furcilia	71	61	2	—	—	—	—	4	8	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—	—	—
L. helicina	1	1	1	—	—	—	—	—	1	1	—
Limacina juv.	—	120	—	—	—	—	—	—	—	—	60
Salpa fusiformis	—	9	35	14	—	—	—	19	63	13	1
Appendicularia	—	3	64	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**151**						**160**		
Date	16. i. 27						7. ii. 27		
Hour	0915–1155						1320–1350		
Position	53° 25′ S, 35° 15′ W						Near Shag Rocks, 53° 43′ 40″ S, 40° 57′ W		
Sounding (m.)	3200						177		
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–50	180–100
Foraminifera	—	—	40	—	—	—	—	—	—
Radiolaria	—	—	—	61	260	90	—	—	120
Medusae	—	—	—	—	2	—	—	—	—
Beroë	—	—	1	1	—	—	—	—	4
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	1	37	18	4	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	2	6	3	—	—	—
S. gazellae	—	—	1	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	60	—	—	—	2	37
Pelagobia longicirrata	—	—	—	—	14	10	—	—	66
Polychaeta juv.	—	—	—	—	40	—	—	—	—
Conchoecia hettacra	—	—	—	34	3	1	—	—	1
Ostracoda juv.	—	—	40	—	160	40	—	—	120
Calanus simillimus	—	—	—	—	—	—	—	—	3
C. propinquus	—	95	77	17	3	4	34	16	93
C. acutus	—	4	117	47	14	4	—	12	202
Rhincalanus gigas	—	—	3	123	4	—	1	33	87
Clausocalanus laticeps	—	4	—	—	—	—	—	—	1
Ctenocalanus vanus	—	716	270	100	—	35	44	138	2,801
Microcalanus pygmaeus	—	—	—	160	28	112	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	2	—
Pareuchaeta antarctica ..	—	—	—	—	6	—	—	—	—
Pareuchaeta sp. juv.	—	—	5	1	—	7	—	—	1
Scolecithricella minor	—	—	45	—	—	—	—	—	5
Pleuromamma robusta	—	—	—	—	7	—	—	—	—
Metridia gerlachei	1	—	20	206	107	5	—	—	—
M. lucens	—	—	—	20	9	—	—	—	2
Oithona frigida	—	—	920	1045	437	681	1100	1888	10,524
Parathemisto gaudichaudi	—	—	—	—	—	—	—	—	—
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	1	4	1	—	—	—	—	—
Cyllopus sp.	—	—	—	6	—	—	—	—	—
Amphipoda, *alia*	—	—	1	4	2	1	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	3	—	—	—	—	—
E. frigida, cyrtopia	—	—	4	—	—	—	—	—	—
E. frigida, furcilia	—	—	1	—	—	1	—	—	3
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	1	—	—	—	—	—
T. vicina ♂	—	1	—	—	1	—	—	—	—
Thysanoessa sp. ♀	—	1	1	1	2	—	—	—	—
Thysanoessa, cyrtopia	22	11	—	—	—	—	6	3	2
Thysanoessa, furcilia	2	17	5	—	—	—	10	10	2
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	2
Limacina balea	—	—	—	—	—	—	—	—	3
L. helicina	—	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	18	91	151	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**161**						**WS 18**		**WS 19**	
Date	14. ii. 27						26. xi. 26		27. xi. 26	
Hour	0905–1100						1710–1730		1025–1100	
Position	57° 21′ 20″ S, 46° 43′ 30″ W						54° 07′ S, 36° 23′ W		54° 00′ 30″ S, 36° 20′ 30″ W	
Sounding (m.)	3459						113		128	
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–0	50–0	100–0
Foraminifera	—	2,400	480	60	—	—	—	—	120	—
Radiolaria	—	480	360	187	274	5	—	—	1680	—
Medusae	—	—	—	1	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—	1
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	40	6	—	—	—	3	—	3
Sagitta maxima	—	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	3	—	—	—	—	—	—
Chaetognatha, *alia*	—	37	—	1	6	1	—	—	—	1
Pelagobia longicirrata	—	980	263	—	—	1	—	—	—	—
Polychaeta juv.	—	—	—	—	—	—	40	—	—	—
Conchoecia hettacra	—	—	—	9	2	—	—	—	—	—
Ostracoda juv.	—	—	120	180	180	—	—	—	—	—
Calanus simillimus	—	—	1	—	—	—	17	6	49	88
C. propinquus	1,197	231	645	28	15	4	—	5	15	21
C. acutus	743	657	1,548	43	7	3	51	201	141	150
Rhincalanus gigas	24	180	275	6	—	—	2	35	5	61
Clausocalanus laticeps	439	4,192	—	—	1	—	—	—	—	18
Ctenocalanus vanus	3,968	3,800	2,557	238	565	8	87	219	457	7
Microcalanus pygmaeus	—	—	—	291	330	64	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	324	7029	688	2889
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	2	6	—	—	—	—	—
Scolecithricella minor	—	—	266	—	25	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	17	112	49	2	—	—	—	—
M. lucens	—	—	27	—	—	2	—	—	—	—
Oithona frigida	12,960	41,298	14,782	1541	730	15	887	2905	1144	4850
Parathemisto gaudichaudi	—	1	—	—	1	1	—	5	4	3
Primno macropa	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	1	1	1	—	—	—	—	—	—
Cyllopus sp.	—	4	1	—	—	1	—	—	—	—
Amphipoda, *alia*	1	—	—	1	4	1	—	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	4	—	—	—	—	—	—
E. frigida, cyrtopia	2	—	—	1	—	—	—	—	—	—
E. frigida, furcilia	1	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	4	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	166	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	7	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	—	—	1	—
Thysanoessa sp. ♀	—	—	1	—	—	—	—	—	1	—
Thysanoessa, cyrtopia	26	—	—	—	—	—	—	—	—	1
Thysanoessa, furcilia	49	—	—	—	—	—	—	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—	—
Limacina juv.	1,920	—	120	—	—	—	—	—	—	—
Salpa fusiformis	—	37	41	33	2	103	—	—	—	—
Appendicularia	965	1,925	245	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 20**				**WS 21**				
Date	28. xi. 26				28. xi. 26				
Hour	0830–0915				1400–1600				
Position	53° 52′ 30″ S, 36° 00′ W				53° 45′ 30″ S, 35° 48′ W				
Sounding (m.)	535				899				
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	50–0	100–50	250–100	500–250	750–500
Foraminifera	—	120	—	40	4	100	100	100	—
Radiolaria	—	—	60	41	—	—	—	—	8
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	3	55	42	—	—	7	—	—
Sagitta maxima	—	—	—	3	—	—	—	—	—
S. planktonis	—	—	2	4	—	—	—	3	2
S. gazellae	—	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	40	—	—	—	—	—
Pelagobia longicirrata	—	—	—	—	—	—	—	2	—
Polychaeta juv.	—	—	60	41	4	—	—	—	—
Conchoecia hettacra	—	—	10	17	—	—	—	3	—
Ostracoda juv.	—	—	—	—	—	—	—	—	—
Calanus simillimus	7	8	30	4	5	2	—	—	—
C. propinquus	3	5	—	—	—	7	6	3	—
C. acutus	17	48	147	49	—	73	10	36	6
Rhincalanus gigas	—	11	98	12	—	6	10	7	—
Clausocalanus laticeps	—	—	—	—	9	—	—	2	—
Ctenocalanus vanus	—	1	942	115	9	—	133	31	11
Microcalanus pygmaeus	—	—	738	461	—	—	—	25	7
Drepanopus pectinatus	76	1523	5	92	—	741	1	—	—
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	8	6	5	—	—	—	1	—
Scolecithricella minor	—	—	227	—	—	—	4	—	—
Pleuromamma robusta	—	—	—	1	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	—
M. lucens	—	—	4	79	—	—	—	45	10
Oithona frigida	—	883	2579	1244	40	3560	1600	448	112
Parathemisto gaudichaudi	4	—	—	—	—	1	—	—	—
Primno macropa	1	1	2	3	—	—	—	—	—
Vibilia antarctica	—	—	—	2	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	2	—	—	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	5	1	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	1	—	—	—	—	—
T. vicina ♂	—	1	2	—	—	—	—	—	—
Thysanoessa sp. ♀	—	1	3	—	—	—	1	—	—
Thysanoessa, cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa, furcilia	—	—	—	—	—	11	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	1	—	—	—	—	—
Appendicularia	300	—	—	40	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 22**							**WS 24**			
Date	30. xi. 26							10. xii. 26			
Hour	1415–1850							1530–1600			
Position	53° 38′ S, 35° 35′ W							54° 12′ 07″ S, 36° 28′ 07″ W			
Sounding (m.)	2260							172–212			
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	1000–0	50–0	100–50	165–100	205–100
Foraminifera	80	360	900	420	200	180	2,400	—	—	—	—
Radiolaria	—	—	60	60	46	89	724	—	—	—	—
Medusae	—	—	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	1	—	—	—	1	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	1	2	—
Eukrohnia hamata	—	26	74	21	9	16	189	2	8	16	2
Sagitta maxima	—	—	—	—	1	2	—	—	—	—	—
S. planktonis	—	—	3	2	—	2	8	—	—	—	—
S. gazellae	—	—	—	—	—	3	3	—	—	—	1
Chaetognatha, *alia*	—	—	—	60	40	60	—	—	60	—	—
Pelagobia longicirrata	43	10	17	10	48	7	10	—	—	—	—
Polychaeta juv.	—	180	300	—	—	60	720	—	60	180	540
Conchoecia hettacra	1	—	13	16	—	2	1	—	—	—	—
Ostracoda juv.	—	—	—	—	—	—	240	—	—	—	—
Calanus simillimus	98	27	30	1	21	—	692	17	4	2	—
C. propinquus	3	5	25	1	—	—	1,181	1	4	2	48
C. acutus	45	43	268	91	31	33	1,412	2	35	33	18
Rhincalanus gigas	7	139	140	36	1	—	254	24	45	63	22
Clausocalanus laticeps	—	—	—	—	—	—	—	—	—	—	46
Ctenocalanus vanus	1	1350	2593	62	—	126	16,692	—	5	9	327
Microcalanus pygmaeus	—	—	—	1540	—	683	3,795	—	—	—	—
Drepanopus pectinatus	6	1	52	—	31	—	—	6351	14,544	2358	1220
Pareuchaeta antarctica	—	—	—	7	—	1	—	—	—	—	—
Pareuchaeta sp. juv.	67	2	157	—	—	—	1	1	2	—	5
Scolecithricella minor	—	—	155	31	—	31	230	—	—	—	—
Pleuromamma robusta	—	—	—	5	9	3	1	—	—	—	—
Metridia gerlachei	—	1	26	119	35	10	805	—	—	—	1
M. lucens	—	—	—	79	130	12	117	—	—	—	1
Oithona frigida	646	6782	8275	1418	224	492	10,139	1020	3,792	1412	600
Parathemisto gaudichaudi	—	3	4	3	—	—	4	—	—	—	1
Primno macropa	—	1	1	—	2	—	8	—	—	—	—
Vibilia antarctica	—	—	1	1	—	—	16	—	—	—	—
Cyllopus sp.	—	—	1	—	—	—	1	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	1	—	—	—	—
Mysidae	—	—	—	—	—	1	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	2	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	35	39	1	—	18	—	—	—	—	—
E. frigida, calyptopis	—	—	2	—	—	2	—	—	—	—	—
Euphausia superba, adult	—	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	1	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	2	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa sp. ♀	—	—	—	—	—	—	1	—	—	—	—
Thysanoessa, cyrtopia	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa, furcilia	2	14	7	—	—	—	5	—	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—	—	—
L. helicina	1	—	—	—	—	1	5	—	—	—	—
Limacina juv.	—	—	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	2	13	17	—	1	163	—	—	—	—
Appendicularia	—	2	60	—	—	60	480	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 26**							**WS 27**	
Date	18. xii. 26							19. xii. 26	
Hour	1800–2215							0600–0700	
Position	53° 33′ 15″ S, 37° 45′ 15″ W							53° 55′ S, 38° 01′ W	
Sounding (m.)	1180							80	
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	750–0	50–0	70–50
Foraminifera	8	160	—	—	692	26	60	28	—
Radiolaria	8	—	—	60	60	46	76	—	20
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	10	83	87	34	9	100	—	—
Sagitta maxima	—	—	—	3	3	—	5	—	—
S. planktonis	—	—	—	6	8	—	4	—	—
S. gazellae	—	—	1	2	—	—	5	—	—
Chaetognatha, *alia*	—	—	40	—	—	—	—	—	—
Pelagobia longicirrata	—	—	—	2	11	65	7	—	—
Polychaeta juv.	4	—	—	—	—	—	—	12	40
Conchoecia hettacra	—	—	11	20	14	—	20	—	—
Ostracoda juv.	—	—	—	—	—	—	—	4	—
Calanus simillimus	6	14	10	—	—	—	129	1	—
C. propinquus	12	38	11	49	1	—	105	1	40
C. acutus	—	49	57	591	59	2	936	—	1
Rhincalanus gigas	—	192	194	192	8	—	250	—	—
Clausocalanus laticeps	—	17	—	5	—	—	—	2	—
Ctenocalanus vanus	—	878	201	311	496	1	176	48	200
Microcalanus pygmaeus	—	—	—	1824	986	—	3561	—	—
Drepanopus pectinatus	223	36	51	—	—	—	—	174	—
Pareuchaeta antarctica	—	—	—	4	—	1	7	—	—
Pareuchaeta sp. juv.	—	—	—	—	8	—	—	—	—
Scolecithricella minor	—	—	273	134	25	—	257	—	—
Pleuromamma robusta	—	—	—	37	20	5	2	—	—
Metridia gerlachei	—	—	39	115	80	25	472	—	—
M. lucens	—	—	49	340	424	8	305	1	—
Oithona frigida	225	3781	2225	3940	920	49	9002	600	661
Parathemisto gaudichaudi	—	—	1	—	—	—	2	1	—
Primno macropa	—	—	1	—	4	—	1	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	1	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	1	1	—	5	—	—
Mysidae	—	—	1	1	—	1	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	1	—	—	—	4	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
Euphausia superba, adult	—	—	—	1	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	1	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	1	—	—	—	—	—
Thysanoessa sp. ♀	1	—	3	2	1	3	—	—	—
Thysanoessa, cyrtopia	—	—	—	—	1	—	—	—	—
Thysanoessa, furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	3	—	46	—	—
Appendicularia	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 28**			**WS 29**				
Date	19. xii. 26			19. xii. 26				
Hour	1000–1100			1315–1520				
Position	53° 48′ 15″ S, 38° 13′ W			53° 41′ 15″ S, 38° 24′ 45″ W				
Sounding (m.)	150–346			614				
Depth of nets (m.) ...	50–0	100–50	145–100	50–0	100–50	250–100	500–250	600–500
Foraminifera	8	480	—	—	—	—	—	23
Radiolaria	—	—	—	—	—	—	—	—
Medusae	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	1	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—
Eukrohnia hamata	2	1	—	—	—	87	28	2
Sagitta maxima	—	—	—	—	—	4	4	1
S. planktonis	—	—	—	—	—	1	1	—
S. gazellae	—	—	—	—	1	1	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—
Pelagobia longicirrata	—	—	—	—	—	7	—	21
Polychaeta juv.	4	—	—	—	—	80	—	—
Conchoecia hettacra	—	—	—	—	—	50	33	—
Ostracoda juv.	—	—	—	—	—	—	120	20
Calanus simillimus	—	—	11	—	—	2	—	—
C. propinquus	2	2	—	4	20	1	—	4
C. acutus	—	—	—	—	9	70	199	12
Rhincalanus gigas	2	9	2	—	10	80	35	—
Clausocalanus laticeps	—	32	—	—	—	—	—	—
Ctenocalanus vanus	112	159	152	—	195	536	—	32
Microcalanus pygmaeus	—	—	—	—	—	257	546	20
Drepanopus pectinatus	—	1657	5777	226	44	133	91	—
Pareuchaeta antarctica	1	—	—	—	—	—	—	4
Pareuchaeta sp. juv.	—	—	—	—	1	8	27	—
Scolecithricella minor	1	50	—	—	—	150	37	6
Pleuromamma robusta	—	—	—	—	—	—	1	1
Metridia gerlachei	—	—	—	—	—	144	369	2
M. lucens	—	—	—	—	—	—	—	181
Oithona frigida	177	8108	600	196	1780	8179	1134	743
Parathemisto gaudichaudi	2	—	—	—	—	—	—	—
Primno macropa	—	1	—	—	—	1	6	—
Vibilia antarctica	—	—	—	—	—	—	3	—
Cyllopus sp.	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	2	—	—	—	—	2
Mysidae	—	—	21	1	—	—	2	4
Euphausia frigida, adult	—	—	—	—	—	1	2	—
E. frigida, cyrtopia	—	—	—	—	—	2	1	—
E. frigida, furcilia	—	—	—	—	—	1	1	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—
Euphausia superba, adult	2	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	—	—
Thysanoessa sp. ♀	—	—	—	—	—	—	1	1
Thysanoessa, cyrtopia	—	—	—	—	—	—	—	—
Thysanoessa, furcilia	—	—	—	—	—	—	—	2
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	16	35	2
Appendicularia	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 30**								**WS 31**	
Date	19–20. xii. 26								20. xii. 26	
Hour	1835–2215								1600–1630	
Position	53° 34′ 15″ S, 38° 36′ 15″ W								54° 52′ S, 35° 36′ W	
Sounding (m.)	2582								76	
Depth of nets (m.) ...	50–0	100–50	250–100	500–330	500–250	750–500	1000–750 (*a*)	1000–750 (*b*)	50–0	70–50
Foraminifera	—	—	—	—	60	—	—	—	—	—
Radiolaria	—	—	—	—	—	14	5	4	—	—
Medusae	—	—	1	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—	2
Ctenophora, *alia*	—	—	—	—	—	—	—	—	1	—
Eukrohnia hamata	—	66	72	24	23	10	2	—	1	2
Sagitta maxima	—	—	1	—	—	—	—	—	—	—
S. planktonis	—	—	2	2	4	4	—	—	—	—
S. gazellae	1	—	2	1	1	—	—	—	—	—
Chaetognatha, *alia*	—	—	40	—	—	120	—	—	—	—
Pelagobia longicirrata	—	—	4	—	2	2	—	—	—	1
Polychaeta juv.	10	—	80	—	—	—	2	—	120	—
Conchoecia hettacra	—	—	30	1	10	—	—	—	—	1
Ostracoda juv.	—	—	—	—	60	120	—	—	—	—
Calanus simillimus	28	2	87	31	48	—	—	—	10	33
C. propinquus	58	6	5	2	—	—	—	—	2	1
C. acutus	57	22	71	17	46	21	—	—	259	234
Rhincalanus gigas	1	115	221	18	15	—	—	—	5	38
Clausocalanus laticeps	8	8	19	—	—	—	—	—	—	12
Ctenocalanus vanus	23	507	1300	—	2	60	—	30	10	272
Microcalanus pygmaeus	16	—	474	324	1901	624	88	16	—	—
Drepanopus pectinatus	326	—	—	—	—	—	—	—	480	937
Pareuchaeta antarctica	—	—	—	1	1	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	33	2	—	—	—	—	—	1
Scolecithricella minor	—	—	86	32	58	12	—	—	—	—
Pleuromamma robusta	—	—	—	6	17	—	—	—	—	—
Metridia gerlachei	—	—	107	298	170	3	1	—	—	12
M. lucens	2	—	—	55	—	—	1	1	—	1
Oithona frigida	340	3482	2873	819	736	1277	128	41	1561	2310
Parathemisto gaudichaudi	—	—	4	—	—	—	—	—	5	8
Primno macropa	—	—	3	—	1	—	—	—	—	—
Vibilia antarctica	—	1	2	1	3	—	—	—	—	—
Cyllopus sp.	—	—	1	1	1	—	—	—	—	—
Amphipoda, *alia*	—	—	2	—	—	—	—	—	—	—
Mysidae	—	—	—	—	—	1	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—	1
E. frigida, calyptopis	—	1	—	—	—	—	—	—	—	—
Euphausia superba, adult	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	1	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	—	—	—	1
Thysanoessa sp. ♀	—	—	1	—	1	—	—	—	—	1
Thysanoessa, cyrtopia	—	—	—	—	—	—	—	—	—	—
Thysanoessa, furcilia	—	1	—	—	—	—	—	—	1	34
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	1	—	—	—	—	—	—
Limacina juv.	—	—	—	—	—	—	—	—	—	—
Salpa fusiformis	1	1	37	20	40	19	—	—	—	—
Appendicularia	10	—	—	—	—	—	—	—	60	—

In the 1000–750 m. column (*a*) is the first sample and (*b*) the second.

Zooplankton Table I (*cont.*)

Station	**WS 33**			**WS 34**		**WS 35**		
Date	21. xii. 26			21. xii. 26		21–22. xii. 26		
Hour	1530–1615			1915–1945		**2305–2350**		
Position	54° 59′ S, 35° 24′ W			55° 06′ S, 35° 11′ W		55° 13′ 15″ S, 34° 59′ W		
Sounding (m.)	135			121		161		
Depth of nets (m.) ...	50–0	100–50	130–100	50–0	100–50	50–0	100–50	150–100
Foraminifera	40	120	—	100	120	180	1110	600
Radiolaria	—	—	120	—	—	—	30	—
Medusae	—	—	—	—	—	—	—	—
Beroë	—	1	—	—	—	—	—	2
Ctenophora, *alia*	—	—	1	—	—	—	—	—
Eukrohnia hamata	—	—	4	—	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	1	—	—	—	90
Pelagobia longicirrata	—	—	—	1	3	3	320	19
Polychaeta juv.	—	—	—	—	—	—	—	120
Conchoecia hettacra	—	—	—	—	—	—	—	—
Ostracoda juv.	—	—	—	—	—	—	—	—
Calanus simillimus	17	16	12	14	119	40	67	1
C. propinquus	37	81	11	26	76	67	130	79
C. acutus	3	41	388	28	106	93	1045	480
Rhincalanus gigas	—	11	50	—	4	6	—	25
Clausocalanus laticeps	2	—	—	—	—	—	40	162
Ctenocalanus vanus	20	300	658	—	402	25	4	1310
Microcalanus pygmaeus	—	—	—	—	—	19	—	—
Drepanopus pectinatus	34	17,353	19,734	1309	8628	4824	478	—
Pareuchaeta antarctica	—	—	—	—	—	—	—	7
Pareuchaeta sp. juv.	—	—	2	—	1	—	4	—
Scolecithricella minor	1	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—
Metridia gerlachei	1	—	—	—	—	—	—	4
M. lucens	—	—	—	—	—	11	7	8
Oithona frigida	125	1,567	3,600	100	1810	422	7170	5341
Parathemisto gaudichaudi	2	13	4	3	13	11	7	2
Primno macropa	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	1
Cyllopus sp.	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—
Mysidae	—	2	20	—	1	—	—	—
Euphausia frigida, adult	—	—	1	—	—	—	—	—
E. frigida, cyrtopia	—	—	2	—	3	1	1	4
E. frigida, furcilia	—	—	1	—	4	1	5	36
E. frigida, calyptopis	—	—	—	—	—	1	—	—
Euphausia superba, adult	—	—	—	—	1	1	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	1	—	—	—	—
Thysanoessa sp. ♀	—	—	—	—	—	—	2	1
Thysanoessa, cyrtopia	—	—	1	1	10	2	5	2
Thysanoessa, furcilia	—	—	20	10	59	27	75	173
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—
L. helicina	3	5	1	2	6	3	6	1
Limacina juv.	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	30	—

Zooplankton Table I (*cont.*)

Station	**WS 36**						**WS 37**			
Date	22. xii. 26						22. xii. 26			
Hour	0430–0645						1450–1530			
Position	55° 20′ 15″ S, 34° 46′ 30″ W						54° 45′ S, 35° 11′ W			
Sounding (m.)	1242						318			
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–50	250–100	310–250
Foraminifera	172	900	1900	2510	1200	200	381	99	600	1200
Radiolaria	6	30	120	60	92	80	3	3	300	180
Medusae	—	—	—	1	—	—	—	—	1	—
Beroë	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	4	24	52	22	1	—	—	61	13
Sagitta maxima	—	—	—	—	1	—	—	—	—	—
S. planktonis	—	—	—	—	1	—	—	—	—	—
S. gazellae	—	—	4	—	2	1	—	—	4	—
Chaetognatha, *alia*	—	—	—	180	—	2	—	—	—	60
Pelagobia longicirrata	—	—	3	19	18	—	—	—	205	19
Polychaeta juv.	2	—	121	330	120	20	—	—	—	300
Conchoecia hettacra	—	—	—	18	7	1	—	1	8	10
Ostracoda juv.	—	—	—	120	240	20	6	—	—	—
Calanus simillimus	—	1	90	1	—	—	10	52	5	—
C. propinquus	16	337	663	180	34	—	19	35	154	30
C. acutus	2	996	1526	399	24	17	1	10	2809	91
Rhincalanus gigas	—	—	28	79	15	—	—	9	114	25
Clausocalanus laticeps	—	41	49	—	—	—	—	3	14	—
Ctenocalanus vanus	52	250	544	3046	114	36	24	348	1380	501
Microcalanus pygmaeus	—	—	197	333	467	132	—	—	1	162
Drepanopus pectinatus	15	—	2	—	—	—	14	85	143	20
Pareuchaeta antarctica	—	—	—	—	12	—	—	—	9	22
Pareuchaeta sp. juv.	—	—	4	12	—	—	—	—	115	20
Scolecithricella minor	—	—	44	166	342	—	—	—	143	41
Pleuromamma robusta	—	—	—	—	24	1	—	—	—	—
Metridia gerlachei	—	—	—	83	116	47	—	—	2	691
M. lucens	—	—	—	104	72	—	—	2	—	37
Oithona frigida	150	4173	8360	3267	363	440	237	434	5516	2089
Parathemisto gaudichaudi	—	1	1	1	—	—	—	1	3	—
Primno macropa	—	—	—	31	3	—	1	—	—	—
Vibilia antarctica	—	—	—	—	1	—	—	—	1	1
Cyllopus sp.	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	2	—	—	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—	3
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	8	—	—	—	—	—	3	—
E. frigida, furcilia	1	—	15	1	—	—	—	—	8	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—
Euphausia superba, adult	—	5	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	1	—	—	—	1	—
Thysanoessa sp. ♀	—	2	—	—	2	—	1	—	—	—
Thysanoessa, cyrtopia	—	—	4	—	—	—	—	—	1	—
Thysanoessa, furcilia	25	46	22	2	—	—	2	4	7	—
Thysanoessa, calyptopis	—	—	1	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—	—
L. helicina	1	8	5	3	—	—	2	1	—	—
Limacina juv.	—	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	1	4	2	—	—	—	—	—	—
Appendicularia	—	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 38**						**WS 39**		
Date	22–23. xii. 26						23. xii. 26		
Hour	**2150–0010**						0600–0630		
Position	54° 01′ S, 35° 14′ W						54° 08′ S, 35° 43′ W		
Sounding (m.)	2103						237		
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–50	232–100
Foraminifera	120	160	1900	2220	600	240	8	—	300
Radiolaria	—	—	60	240	205	255	—	—	120
Medusae	—	—	—	—	1	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	36	43	11	8	—	—	60
Sagitta maxima	—	—	—	1	—	—	—	—	—
S. planktonis	—	—	—	1	—	—	—	—	—
S. gazellae	1	—	1	—	1	—	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	3	60
Pelagobia longicirrata	—	1	321	1	11	10	—	—	29
Polychaeta juv.	—	—	60	60	120	60	—	—	180
Conchoecia hettacra	—	—	4	90	4	2	—	—	15
Ostracoda juv.	—	—	60	—	120	60	—	—	—
Calanus simillimus	459	26	1	—	—	—	—	10	66
C. propinquus	32	45	131	—	6	—	1	3	101
C. acutus	—	91	490	102	15	13	—	8	107
Rhincalanus gigas	—	—	49	75	2	—	—	—	140
Clausocalanus laticeps	60	9	18	—	—	—	—	2	25
Ctenocalanus vanus	—	158	1600	2	79	191	3	66	942
Microcalanus pygmaeus	—	113	—	1763	791	642	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	29	—	1613
Pareuchaeta antarctica	—	—	—	—	—	2	—	—	—
Pareuchaeta sp. juv.	—	1	85	36	4	23	—	—	37
Scolecithricella minor	—	—	220	—	20	101	—	—	80
Pleuromamma robusta	—	—	30	—	4	1	—	—	—
Metridia gerlachei	—	15	464	232	196	244	—	—	4
M. lucens	—	9	—	101	79	—	3	1	—
Oithona frigida	120	4480	—	2117	1266	149	96	—	7128
Parathemisto gaudichaudi	3	1	—	—	—	—	—	8	3
Primno macropa	—	—	—	—	—	1	—	1	—
Vibilia antarctica	—	—	—	—	—	—	—	2	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Mysidae	—	—	—	—	—	4	—	—	—
Euphausia frigida, adult	—	3	—	—	—	—	—	—	—
E. frigida, cyrtopia	3	—	—	—	—	—	—	—	1
E. frigida, furcilia	6	10	4	1	—	—	—	—	10
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
Euphausia superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	1	1	—	—	—	—	—
T. vicina ♂	1	—	—	—	—	—	—	—	—
Thysanoessa sp. ♀	7	1	2	—	—	—	—	—	2
Thysanoessa, cyrtopia	2	—	—	—	—	—	—	—	2
Thysanoessa, furcilia	9	14	26	—	—	—	2	—	4
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	18	—	—	—	—	—	—	—	1
Limacina juv.	—	—	—	—	—	—	—	—	—
Salpa fusiformis	69	8	2	32	—	—	—	15	—
Appendicularia	—	—	—	1	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 40**			**WS 41**			**WS 42**		
Date	7. i. 27			7. i. 27			7. i. 27		
Hour	0630–0730			1400–1440			1800–1835		
Position	55° 09′ S, 35° 58′ W			54° 32′ 45″ S, 36° 43′ 45″ W			54° 41′ 45″ S, 36° 47′ W		
Sounding (m.)	183			140			175		
Depth of nets (m.) ...	50–0	100–50	175–100	50–0	100–50	140–100	50–0	100–50	170–100
Foraminifera	60	2,460	7480	360	30	120	—	—	120
Radiolaria	—	—	180	—	—	—	—	—	—
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	1	—	—	—	1
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	5	9	40	2	—	—	—	4	8
Sagitta maxima	—	3	2	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	1	1	—	—	—	—	—
Chaetognatha, *alia*	—	—	60	—	—	—	—	—	—
Pelagobia longicirrata	—	19	18	—	31	62	—	—	66
Polychaeta juv.	120	1,200	360	—	—	—	—	240	—
Conchoecia hettacra	—	—	—	—	—	—	—	—	—
Ostracoda juv.	—	60	—	—	—	—	—	—	—
Calanus simillimus	1	7	—	61	4	—	19	8	8
C. propinquus	97	123	110	41	4	3	—	63	30
C. acutus	179	366	318	1670	127	173	18	183	119
Rhincalanus gigas	29	69	83	—	3	—	2	20	7
Clausocalanus laticeps	—	100	—	—	—	—	—	—	—
Ctenocalanus vanus	1653	2,537	53	413	—	—	—	710	266
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	227	—	18	3554	3939	16,066	4699	3228	1409
Pareuchaeta antarctica	—	—	10	—	—	22	—	—	—
Pareuchaeta sp. juv.	—	—	56	—	3	—	—	—	2
Scolecithricella minor	62	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	1	—	—	—	—	—	—
Metridia gerlachei	—	—	20	—	—	—	—	—	—
M. lucens	—	—	57	—	—	—	—	—	12
Oithona frigida	8545	17,010	3797	—	480	240	1265	6253	1000
Parathemisto gaudichaudi	1	—	—	6	1	—	4	15	—
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	1	—	—	—
Mysidae	—	—	2	—	—	2	—	—	12
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	7	30	1	1	—	—	2	1
E. frigida, furcilia	—	19	15	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
Euphausia superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	1	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	—	3	—
Thysanoessa sp. ♀	—	—	—	—	—	—	2	—	—
Thysanoessa, cyrtopia	12	10	2	5	2	—	—	1	—
Thysanoessa, furcilia	18	28	2	18	—	—	3	1	—
Thysanoessa, calyptopis	—	3	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	1	—	—	—	—	—	1	1	—
Limacina juv.	180	1,500	420	—	—	—	—	120	—
Salpa fusiformis	—	—	1	—	—	—	—	—	—
Appendicularia	—	661	180	—	—	—	60	182	—

Zooplankton Table I (*cont.*)

Station	**WS 43**			**WS 44**					
Date	7–8. i. 27			8. i. 27					
Hour	**2230–2330**			0500–0740					
Position	54° 54′ S, 36° 50′ W			55° 06′ S, 36° 57′ W					
Sounding (m.)	200			1470					
Depth of nets (m.) ...	50–0	100–50	200–100	50–0	100–50	250–100	500–250	750–500	1000–750
Foraminifera	80	400	1600	381	1,800	7430	5120	240	1520
Radiolaria	—	—	—	—	120	320	123	60	140
Medusae	—	—	—	—	—	—	—	2	1
Beroë	—	—	—	—	—	1	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	4	8	30	—	10	22	93	12	14
Sagitta maxima	—	—	—	—	—	—	1	—	—
S. planktonis	—	—	—	—	—	—	3	2	—
S. gazellae	—	—	6	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	120	—	—	160	80	—	—
Pelagobia longicirrata	161	43	48	—	3	100	34	13	6
Polychaeta juv.	—	—	180	3	—	—	—	—	—
Conchoecia hettacra	—	—	1	—	1	—	35	2	—
Ostracoda juv.	—	—	—	—	—	—	80	80	—
Calanus simillimus	5	4	—	3	6	5	—	—	—
C. propinquus	28	48	56	4	244	40	27	1	2
C. acutus	53	145	132	4	891	176	74	38	2
Rhincalanus gigas	7	5	23	1	5	10	125	—	—
Clausocalanus laticeps	—	—	—	7	47	14	35	—	—
Ctenocalanus vanus	60	256	456	8	4,029	202	751	15	4
Microcalanus pygmaeus	—	—	256	—	—	—	656	613	175
Drepanopus pectinatus	1090	2	143	—	7,442	412	12	—	263
Pareuchaeta antarctica	—	—	—	—	—	—	12	—	2
Pareuchaeta sp. juv.	1	—	14	—	1	27	1	22	—
Scolecithricella minor	1	20	77	—	—	34	—	—	—
Pleuromamma robusta	—	—	13	—	—	—	2	25	—
Metridia gerlachei	—	2	2	—	—	—	67	36	18
M. lucens	—	—	—	—	—	44	64	1	—
Oithona frigida	730	1485	4404	96	11,718	3545	1298	621	548
Parathemisto gaudichaudi	—	—	—	—	2	—	—	—	—
Primno macropa	—	1	—	1	1	—	1	5	1
Vibilia antarctica	—	—	—	—	1	2	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	2	1	—	—	1	—	—
Mysidae	3	7	—	—	—	—	—	1	—
Euphausia frigida, adult	—	—	—	—	—	—	1	1	—
E. frigida, cyrtopia	2	—	—	1	1	1	8	—	—
E. frigida, furcilia	—	—	—	—	3	1	—	—	—
E. frigida, calyptopis	—	—	—	—	4	5	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	1	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	1	1	—
Thysanoessa sp. ♀	—	—	3	—	—	—	1	3	—
Thysanoessa, cyrtopia	4	6	—	—	3	—	—	—	—
Thysanoessa, furcilia	3	6	—	5	29	5	2	2	—
Thysanoessa, calyptopis	—	—	—	—	2	—	1	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	1	—	—	—	—	—	1
Limacina juv.	40	40	—	24	1,020	40	40	—	—
Salpa fusiformis	—	—	—	—	12	14	1	1	—
Appendicularia	—	41	240	—	60	1	—	40	—

Zooplankton Table I (*cont.*)

Station	**WS 45**			**WS 46**			**WS 47**		
Date	8. i. 27			8. i. 27			9. i. 27		
Hour	1650–1735			**2150–2240**			**0130–0205**		
Position	54° 38′ 30″ S, 37° 30′ 55″ W			54° 20′ 15″ S, 37° 32′ 30″ W			54° 22′ S, 37° 50′ W		
Sounding (m.)	180			194			160		
Depth of nets (m.) ...	50–0	100–50	170–100	50–0	100–50	171–100	50–0	100–50	150–100
Foraminifera	360	60	420	32	—	48	—	60	20
Radiolaria	—	—	—	—	—	—	—	—	—
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	30	—	1	2	2	—	9
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	1	—	—
Chaetognatha, *alia*	—	—	60	—	—	—	—	—	—
Pelagobia longicirrata	—	126	135	—	—	28	190	5	—
Polychaeta juv.	120	—	—	8	67	—	—	—	—
Conchoecia hettacra	—	—	—	—	1	—	—	—	—
Ostracoda juv.	—	—	—	—	—	—	—	—	—
Calanus simillimus	6	3	2	1	4	—	8	2	1
C. propinquus	61	303	125	40	125	9	38	45	16
C. acutus	416	901	428	37	561	8	208	180	18
Rhincalanus gigas	4	27	37	—	22	2	28	9	5
Clausocalanus laticeps	—	2	17	4	—	—	—	—	1
Ctenocalanus vanus	365	3820	807	131	8	100	485	4	128
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	913	490	33	39	839	16	2793	1758	317
Pareuchaeta antarctica	—	—	—	3	15	—	—	—	2
Pareuchaeta sp. juv.	—	—	5	—	—	4	—	4	—
Scolecithricella minor	14	—	36	—	—	4	—	—	5
Pleuromamma robusta	—	—	—	—	—	—	—	—	2
Metridia gerlachei	—	—	241	—	25	1	—	10	2
M. lucens	—	—	15	1	14	1	—	5	2
Oithona frigida	1020	7740	3142	492	4916	246	2736	2788	591
Parathemisto gaudichaudi	2	—	—	—	—	—	1	—	—
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	1	—	2	—	—	—	1
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	2	—	—	—	—	—	—
Mysidae	—	4	6	2	9	1	2	35	66
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	2	—	1	7	6	—	—	1	1
E. frigida, furcilia	2	2	2	—	—	—	—	1	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	1	—	—
T. vicina ♂	—	—	—	—	—	—	1	4	1
Thysanoessa sp. ♀	—	—	—	1	2	—	—	3	—
Thysanoessa, cyrtopia	7	10	2	4	3	—	—	1	—
Thysanoessa, furcilia	27	19	—	8	6	2	—	4	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	2	—
Limacina juv.	60	300	60	—	—	4	—	60	—
Salpa fusiformis	—	—	4	—	—	—	—	—	—
Appendicularia	420	—	—	16	—	8	120	—	—

Zooplankton Table I (*cont.*)

Station	**WS 48**			**WS 49**			**WS 50**		
Date	9. i. 27			9. i. 27			9. i. 27		
Hour	0510–0545			0820–0900			1240–1315		
Position	54° 24′ S, 38° 09′ W			54° 28′ S, 38° 22′ 15″ W			54° 30′ 30″ S, 38° 40′ 30″ W		
Sounding (m.)	224			223			230		
Depth of nets (m.) ...	50–0	100–50	224–100	50–0	100–50	225–100	50–0	100–50	225–100
Foraminifera	400	180	60	—	—	80	16	20	—
Radiolaria	—	—	—	—	—	—	—	8	—
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	1	1	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	1	16	—	—	9	—	—	28
Sagitta maxima	—	—	—	—	—	1	—	—	2
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	4	—	—	1	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Pelagobia longicirrata	—	—	—	61	—	12	—	—	9
Polychaeta juv.	—	240	120	—	60	—	4	—	—
Conchoecia hettacra	—	—	—	—	—	—	—	—	1
Ostracoda juv.	—	—	—	—	—	—	—	—	—
Calanus simillimus	13	19	—	1	50	4	10	13	270
C. propinquus	13	20	14	2	79	22	5	6	478
C. acutus	16	46	13	31	85	7	—	4	194
Rhincalanus gigas	2	4	—	1	6	5	—	2	12
Clausocalanus laticeps	2	—	—	—	—	—	—	5	41
Ctenocalanus vanus	6	7	58	261	7	5	22	220	537
Microcalanus pygmaeus	—	—	2	—	—	55	—	—	—
Drepanopus pectinatus	1143	10,166	8124	346	15,862	304	179	260	5840
Pareuchaeta antarctica	1	—	31	—	1	32	—	—	6
Pareuchaeta sp. juv.	—	—	4	3	1	—	1	—	—
Scolecithricella minor	—	—	—	—	—	13	—	1	53
Pleuromamma robusta	—	—	—	—	1	2	—	—	—
Metridia gerlachei	—	—	6	—	—	93	—	—	13
M. lucens	—	—	—	—	—	7	1	2	—
Oithona frigida	263	3,819	842	1680	4,170	808	254	732	5792
Parathemisto gaudichaudi	—	—	—	1	3	—	—	—	—
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	1	—	—	—
Mysidae	1	—	43	—	6	68	2	—	8
Euphausia frigida, adult	—	—	—	—	1	1	—	—	—
E. frigida, cyrtopia	—	—	1	2	—	—	—	—	3
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	1
T. vicina ♂	—	—	4	—	1	—	—	—	—
Thysanoessa sp. ♀	—	—	3	—	2	1	—	—	1
Thysanoessa, cyrtopia	—	—	—	—	14	—	—	2	—
Thysanoessa, furcilia	—	—	—	2	3	2	1	1	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	1	—	—	—	—	2	—	—
Limacina juv.	—	120	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	—	—	—
Appendicularia	—	—	—	120	120	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 51**			**WS 52**			**WS 54**				
Date	9. i. 27			10. i. 27			12. i. 27				
Hour	1535–1640			0630–0800			0320–0420				
Position	54° 34′ S, 38° 57′ W			54° 03′ 30″ S, 38° 35′ W			53° 29′ S, 37° 13′ 45″ W				
Sounding (m.)	210			184			2281				
Depth of nets (m.) ...	50–0	100–50	200–100	50–0	100–50	180–100	50–0	100–50	100–0	250–100	500–250
Foraminifera	—	780	2240	12	280	40	6	50	180	240	360
Radiolaria	—	—	—	—	—	—	—	—	180	180	—
Medusae	—	—	—	—	—	—	—	—	—	—	—
Beroë	1	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	1	26	—	1	8	—	—	—	17	16
Sagitta maxima	—	—	2	—	—	—	—	—	—	2	—
S. planktonis	—	—	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	2	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—	—	—
Pelagobia longicirrata	—	130	18	—	—	41	—	—	—	—	—
Polychaeta juv.	—	—	80	4	—	—	—	—	—	—	—
Conchoecia hettacra	—	—	8	—	—	2	—	—	—	—	10
Ostracoda juv.	—	—	—	—	—	—	—	—	—	—	60
Calanus simillimus	—	7	1	—	2	2	—	4	—	1	—
C. propinquus	—	27	97	1	20	3	1	72	49	94	11
C. acutus	—	601	564	—	8	45	—	8	12	408	242
Rhincalanus gigas	—	7	27	4	51	53	—	—	—	1	56
Clausocalanus laticeps	—	—	—	1	17	—	1	8	23	—	—
Ctenocalanus vanus	—	896	263	16	89	313	3	279	743	849	—
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	31	—	—
Drepanopus pectinatus	1	70	1800	7	12	109	—	—	2	—	110
Pareuchaeta antarctica	—	—	65	1	—	2	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	49	—	—	—	—	—	4	—	9
Scolecithricella minor	—	16	74	1	—	10	—	—	31	43	44
Pleuromamma robusta	—	—	—	—	—	—	—	—	—	—	9
Metridia gerlachei	—	—	15	—	—	—	—	—	—	24	92
M. lucens	—	—	27	—	—	—	—	—	7	3	132
Oithona frigida	—	3622	6974	56	3830	3117	21	2610	4037	3638	350
Parathemisto gaudichaudi	—	—	—	—	2	—	—	—	—	2	2
Primno macropa	—	—	—	—	—	—	—	—	—	2	1
Vibilia antarctica	—	—	—	—	—	—	1	—	—	—	6
Cyllopus sp.	—	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	30	—	—	—	—	—	—	—	—	—
Mysidae	—	35	38	—	—	1	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	2	—	—	—	—	—	—	15	—
E. frigida, furcilia	—	—	1	—	—	—	—	—	1	4	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	1	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—	1
T. vicina ♂	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa sp. ♀	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa, cyrtopia	—	—	—	—	—	—	9	7	5	3	—
Thysanoessa, furcilia	—	5	—	—	—	—	1	24	14	9	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—	—	—
L. helicina	1	—	—	—	—	—	—	—	—	—	—
Limacina juv.	—	540	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	—	—	—	—	158
Appendicularia	—	30	—	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 61**						**WS 63**					
Date	18. i. 27						20–21. i. 27					
Hour	0230–0530						1830–2030					
Position	52° 37′ 30″ S, 37° 06′ 30″ W						54° 36′ S, 39° 14′ W					
Sounding (m.)	1892–2201						1752					
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–50	250–100	500–250	750–500	1000–750
Foraminifera	40	60	—	120	—	—	37	780	1380	840	240	60
Radiolaria	—	—	—	196	7	84	5	—	420	63	110	259
Medusae	—	—	—	—	—	3	—	—	—	—	—	2
Beroë	—	—	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	4	36	42	24	14	1	14	—	138	—	—
Sagitta maxima	—	—	—	3	2	—	—	—	—	7	—	—
S. planktonis	—	—	—	3	—	2	—	—	—	—	—	—
S. gazellae	—	2	5	—	2	1	—	1	—	5	—	—
Chaetognatha, *alia*	—	—	60	—	—	—	—	—	65	180	27	14
Pelagobia longicirrata	—	—	10	12	3	220	—	11	155	3	14	9
Polychaeta juv.	—	60	—	—	40	—	—	—	—	61	80	—
Conchoecia hettacra	1	6	20	28	2	3	—	—	1	29	7	3
Ostracoda juv.	—	—	—	300	81	40	3	—	120	180	40	120
Calanus simillimus	1	—	—	—	—	—	—	25	20	—	—	—
C. propinquus	34	64	6	4	3	—	37	177	116	54	9	2
C. acutus	—	6	154	162	73	1	—	774	1722	1176	100	33
Rhincalanus gigas	—	—	5	111	15	1	—	6	38	195	10	—
Clausocalanus laticeps	3	35	—	—	—	—	—	51	113	—	—	—
Ctenocalanus vanus	53	1193	12	247	206	127	—	1591	1235	176	45	74
Microcalanus pygmaeus	8	—	510	2436	164	685	—	—	—	849	402	255
Drepanopus pectinatus	1	4	—	—	—	—	—	1334	—	262	—	—
Pareuchaeta antarctica	—	—	24	—	—	—	—	—	—	39	3	2
Pareuchaeta sp. juv.	—	11	—	7	5	—	—	—	56	—	10	4
Scolecithricella minor	—	27	302	—	10	—	—	—	282	2	8	—
Pleuromamma robusta	—	—	—	5	3	—	—	—	—	9	3	—
Metridia gerlachei	2	218	182	786	14	100	—	—	42	60	407	39
M. lucens	19	3	64	1	81	2	—	—	—	144	8	—
Oithona frigida	114	4288	3868	614	275	124	50	8370	6843	1365	758	70
Parathemisto gaudichaudi	—	1	—	1	—	—	—	1	1	2	—	—
Primno macropa	—	—	1	2	1	2	—	—	2	2	2	2
Vibilia antarctica	—	—	2	3	—	—	—	—	—	—	—	—
Cyllopus sp.	1	—	1	1	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	1	—	1	—	—	—	—	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	2	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	6	—	2	—	—	—	6	1	—	—	—
E. frigida, furcilia	—	1	—	—	—	—	—	7	3	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	1	3	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	2	—	—	—	—	—	—	—
T. vicina ♂	—	1	—	1	—	—	—	—	—	—	—	—
Thysanoessa sp. ♀	—	3	6	3	—	—	—	—	—	—	—	—
Thysanoessa, cyrtopia	7	13	—	—	—	—	5	3	—	—	—	—
Thysanoessa, furcilia	1	10	2	—	—	—	3	10	5	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	10	2	—	—	—
Limacina balea	—	—	—	—	—	—	—	125	—	—	—	—
L. helicina	—	—	1	—	1	—	—	—	—	—	—	—
Limacina juv.	—	180	—	—	40	—	—	—	120	—	—	—
Salpa fusiformis	12	29	17	28	8	1	—	—	4	30	1	—
Appendicularia	—	—	—	—	—	—	—	64	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 67**						
Date	20. ii. 27						
Hour	0615–1030						
Position	53° 19′ S, 45° 16′ W						
Sounding (m.)	1839						
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	1000–300
Foraminifera	160	—	—	—	—	60	—
Radiolaria	—	—	120	120	9	14	33
Medusae	—	—	—	—	1	—	—
Beroë	—	—	—	—	1	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—
Eukrohnia hamata	4	25	22	79	23	20	118
Sagitta maxima	—	—	1	8	—	1	1
S. planktonis	—	—	—	1	5	1	3
S. gazellae	—	—	—	—	—	—	2
Chaetognatha, *alia*	—	60	180	120	—	120	60
Pelagobia longicirrata	—	—	3	—	1	1	—
Polychaeta juv.	—	—	61	—	—	—	—
Conchoecia hettacra	—	—	—	16	4	1	14
Ostracoda juv.	—	—	368	60	60	180	180
Calanus simillimus	1	244	4	—	2	37	1
C. propinquus	44	50	22	208	315	8073	54
C. acutus	1	33	56	531	57	67	316
Rhincalanus gigas	—	61	17	209	108	11	238
Clausocalanus laticeps	1	—	15	—	1	—	27
Ctenocalanus vanus	9	1,283	1,387	208	—	646	78
Microcalanus pygmaeus	—	—	—	—	—	2	413
Drepanopus pectinatus	—	—	—	—	—	—	—
Pareuchaeta antarctica	—	—	—	23	27	266	48
Pareuchaeta sp. juv.	—	—	13	1	1	—	—
Scolecithricella minor	—	27	108	82	—	112	38
Pleuromamma robusta	—	—	—	45	19	78	37
Metridia gerlachei	—	—	—	—	1	2	—
M. lucens	—	—	1245	1060	131	156	512
Oithona frigida	479	19,665	15,912	2154	165	2421	2370
Parathemisto gaudichaudi	1	1	1	1	—	—	—
Primno macropa	—	—	—	—	—	3	—
Vibilia antarctica	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	2
Mysidae	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	4
E. frigida, furcilia	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—
T. vicina ♂	—	—	—	—	—	—	—
Thysanoessa sp. ♀	—	—	—	1	—	2	—
Thysanoessa, cyrtopia	3	7	—	1	1	—	2
Thysanoessa, furcilia	—	1	—	1	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—
Limacina balea	5	25	1	—	—	—	—
L. helicina	—	—	—	—	—	—	—
Limacina juv.	140	660	—	—	20	—	60
Salpa fusiformis	—	—	—	20	16	5	1
Appendicularia	1	180	—	—	—	180	—

Zooplankton Table I (*cont.*)

Station	**WS 68**						**WS 69**					
Date	21. ii. 27						22. ii. 27					
Hour	**0215–0452**						**0015–0800**					
Position	52° 53′ S, 48° 48′ W						52° 19′ S, 52° 11′ W					
Sounding (m.)	3197						2743					
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–50	250–100	500–250	750–500	1000–750
Foraminifera	60	80	40	—	—	—	240	660	1,200	120	240	—
Radiolaria	60	40	—	—	186	111	—	—	420	360	5	246
Medusae	—	—	—	1	1	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—	1	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	29	100	66	15	57	5	24	93	85	53	48	45
Sagitta maxima	—	—	4	—	3	1	—	6	5	8	2	3
S. planktonis	—	—	—	—	—	—	—	—	—	—	—	1
S. gazellae	—	—	—	2	—	—	3	3	—	3	1	1
Chaetognatha, *alia*	—	40	120	—	—	—	—	—	180	—	60	—
Pelagobia longicirrata	—	—	—	—	3	—	—	—	—	—	—	—
Polychaeta juv.	—	—	—	—	—	—	60	—	—	1	—	—
Conchoecia hettacra	—	—	—	—	2	—	—	—	—	1	3	1
Ostracoda juv.	—	47	320	127	120	2	—	—	372	103	12	184
Calanus simillimus	30	29	3	—	1	—	2	248	580	3	1	160
C. propinquus	3526	548	27	—	3	31	1919	951	1,683	334	293	15
C. acutus	—	9	3	—	112	21	—	—	—	3	2	42
Rhincalanus gigas	1	53	2	34	22	12	—	125	57	68	44	76
Clausocalanus laticeps	21	14	44	94	—	—	323	—	154	106	71	—
Ctenocalanus vanus	1149	1980	914	255	2	35	1919	515	520	—	272	426
Microcalanus pygmaeus	—	—	156	500	234	86	—	—	—	272	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	4	12	4	—	6	2	3	25	114	3	36	14
Pareuchaeta sp. juv.	—	—	—	6	—	—	—	—	—	—	—	5
Scolecithricella minor	14	21	133	—	—	—	11	—	153	53	—	—
Pleuromamma robusta	—	2	66	12	2	—	—	—	62	110	129	7
Metridia gerlachei	—	—	—	—	—	—	—	—	—	—	—	—
M. lucens	448	27	369	383	67	1	57	1505	1,072	695	325	4
Oithona frigida	4179	1652	3428	3618	2324	394	1570	4446	11,606	6690	1649	8
Parathemisto gaudichaudi	6	2	—	—	2	—	2	—	1	3	2	1
Primno macropa	—	4	5	—	3	—	—	—	14	1	9	12
Vibilia antarctica	—	—	—	—	—	—	—	2	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	3	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	1	—	—	—	—	—	121	2
Mysidae	—	—	—	—	—	—	—	—	—	—	—	1
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	1	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—	—	—	—
T. vicina ♂	—	11	1	—	—	2	—	2	11	—	—	—
Thysanoessa sp. ♀	2	7	—	—	—	—	—	—	21	2	1	—
Thysanoessa, cyrtopia	—	20	5	—	—	—	23	24	47	—	3	3
Thysanoessa, furcilia	14	—	—	—	—	—	3	4	4	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—	—	—
Limacina balea	9	20	2	3	2	—	17	1	16	6	—	—
L. helicina	—	—	—	—	—	—	—	—	—	—	—	—
Limacina juv.	—	40	—	—	—	20	360	180	720	60	60	—
Salpa fusiformis	—	—	1	—	—	—	7	51	19	25	4	—
Appendicularia	60	40	—	—	60	—	60	120	420	—	60	—

Zooplankton Table I (*cont.*)

Station	**WS 70**						**WS 110**					
Date	22–23. ii. 27						26. v. 27					
Hour	**2145–0026**						**1100–1600**					
Position	51° 58′ S, 55° 42′ W						53° 46′ S, 35° 47′ W					
Sounding (m.)	—						988					
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–50	250–100	500–300	750–500	1000–750
Foraminifera	—	—	—	—	60	—	—	—	—	—	20	—
Radiolaria	240	—	5	302	193	314	—	—	60	1	48	74
Medusae	—	—	—	—	—	2	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	7	70	50	27	63	41	—	16	82	14	15	58
Sagitta maxima	—	—	3	1	—	4	—	—	—	—	—	1
S. planktonis	—	—	—	—	—	1	—	—	—	—	—	—
S. gazellae	—	—	—	1	7	—	—	—	3	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	60	—	—	—	40	—	—
Pelagobia longicirrata	—	—	—	—	—	—	—	—	—	—	—	1
Polychaeta juv.	—	—	—	60	121	—	20	—	60	—	—	—
Conchoecia hettacra	—	—	—	2	—	—	—	—	3	4	—	9
Ostracoda juv.	—	1	553	135	12	260	—	—	60	40	—	420
Calanus simillimus	—	—	6	2	—	—	9	15	9	1	56	2
C. propinquus	6530	6	264	14	99	79	9	132	33	147	42	881
C. acutus	—	2	—	4	1	—	—	3	8	9	12	114
Rhincalanus gigas	—	—	66	17	124	141	17	15	131	190	9	212
Clausocalanus laticeps	344	—	—	—	—	711	33	30	50	—	—	—
Ctenocalanus vanus	1720	44	76	20	237	237	268	100	449	—	1	238
Microcalanus pygmaeus	344	154	16	353	85	326	—	—	—	1	15	1404
Drepanopus pectinatus	—	—	—	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	—	—	3	7	15	91	8	—	5	8	5	24
Pareuchaeta sp. juv.	—	—	—	13	—	—	—	—	—	—	—	—
Scolecithricella minor	1032	—	30	—	—	158	—	—	—	—	—	—
Pleuromamma robusta	688	—	224	197	68	7	—	1	—	118	1	48
Metridia gerlachei	—	—	—	—	—	—	—	—	—	—	—	—
M. lucens	7224	44	51	47	338	397	112	34	765	452	123	1735
Oithona frigida	206	1076	2681	4046	2694	3064	740	765	10,423	1430	250	5094
Parathemisto gaudichaudi	483	6	1	1	2	—	—	—	—	—	—	—
Primno macropa	—	—	4	6	6	7	—	1	3	—	1	3
Vibilia antarctica	13	3	—	—	—	—	—	—	—	—	—	—
Cyllopus sp.	2	1	—	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	2	—	1	2	—	3	—	—	—	—	—	121
Mysidae	—	—	—	—	—	—	—	—	—	—	—	3
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—	4	—	7
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—	—	—	7
E. frigida, furcilia	—	—	—	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	1	—	—	—	—	—	—	—	—
T. vicina ♂	27	—	—	2	—	1	5	—	—	—	—	—
Thysanoessa sp. ♀	—	10	—	—	1	—	—	—	1	—	—	—
Thysanoessa, cyrtopia	7	16	5	—	1	—	—	3	—	—	—	—
Thysanoessa, furcilia	2	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	1	6	31	6	5	—	—
L. helicina	—	—	—	—	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	—	—	—	120	180	60	—	—	—
Salpa fusiformis	42	16	7	—	1	4	—	—	—	—	—	—
Appendicularia	—	—	—	120	—	—	—	—	—	—	—	—

Zooplankton Table I (*cont.*)

Station	**WS 111**						**WS 112**		
Date	26–27. v. 27						27. v. 27		
Hour	2115–0045						1100–1150		
Position	53° 39′ S, 35° 34′ W						53° 54′ 30″ S, 36° 06′ W		
Sounding (m.)	1500						155		
Depth of nets (m.) ...	50–0	100–50	250–100	500–250	750–500	1000–750	50–0	100–50	150–100
Foraminifera	—	—	60	240	40	180	20	—	—
Radiolaria	—	—	60	—	7	60	—	—	—
Medusae	—	—	—	—	—	1	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	17	42
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	1	2
Chaetognatha, *alia*	—	—	—	—	3	10	—	—	—
Pelagobia longicirrata	—	—	—	—	—	—	—	—	—
Polychaeta juv.	—	—	—	—	—	—	—	—	30
Conchoecia hettacra	—	—	3	—	—	—	—	—	—
Ostracoda juv.	—	—	120	2	—	—	—	—	—
Calanus simillimus	7	—	—	—	3	—	8	15	20
C. propinquus	24	19	11	28	33	54	10	219	338
C. acutus	—	—	3	3	5	16	—	1	4
Rhincalanus gigas	—	—	—	45	18	59	1	9	24
Clausocalanus laticeps	16	—	—	17	—	—	—	31	284
Ctenocalanus vanus	270	558	—	853	1	—	200	223	292
Microcalanus pygmaeus	—	—	169	1	—	73	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	3	4	3	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	44	24	—	—	—	—	—	23
Pleuromamma robusta	—	1	2	—	—	1	—	—	—
Metridia gerlachei	31	—	—	—	—	—	—	—	—
M. lucens	67	1412	2,165	375	144	524	—	3	175
Oithona frigida	732	7040	13,069	4819	485	498	1682	3640	9198
Parathemisto gaudichaudi	—	—	—	—	—	—	—	—	—
Primno macropa	—	—	—	1	1	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	1	—	—	—
Mysidae	—	—	—	—	1	—	—	—	—
Euphausia frigida, adult	4	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	2	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba, adult	—	1	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	5	—	—	1	2
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	—
T. vicina ♂	2	3	—	—	—	—	3	1	—
Thysanoessa sp. ♀	1	—	—	—	—	—	2	2	—
Thysanoessa, cyrtopia	1	7	2	1	1	—	16	2	2
Thysanoessa, furcilia	—	—	—	—	—	—	—	1	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	20	8	11	14	20	1	41	46	11
L. helicina	—	—	—	—	—	—	—	—	—
Limacina juv.	40	—	—	—	—	—	20	240	120
Salpa fusiformis	—	—	—	—	—	—	—	—	—
Appendicularia	43	—	—	—	—	—	—	94	33

Zooplankton Table I (*cont.*)

Station	**WS 112 A***			**WS 113**			**WS 114**		
Date	27. v. 27			28. v. 27			28. v. 27		
Hour	0915?–1000			0900–0945			1215–1305		
Position	*			54° 07′ S, 36° 24′ W			54° 00′ S, 36° 12′ W		
Sounding (m.)	—			155			163		
Depth of nets (m.) ...	50–0 A	50–0 B	100–50	50–0	100–50	150–100	50–0	100–50	150–100
Foraminifera	—	20	—	—	—	—	—	—	—
Radiolaria	—	40	—	—	—	—	—	—	—
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	1	—	—	—	—
Eukrohnia hamata	4	—	—	—	9	6	3	9	29
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	1	—	—	—	2
Chaetognatha, *alia*	—	—	—	4	—	—	—	—	—
Pelagobia longicirrata	—	—	—	—	—	21	—	—	—
Polychaeta juv.	—	—	—	—	—	—	—	—	—
Conchoecia hettacra	—	—	—	—	—	—	—	—	—
Ostracoda juv.	—	—	—	—	—	20	—	—	—
Calanus simillimus	2	2	51	1	101	98	1	7	3
C. propinquus	18	36	100	29	107	137	11	24	28
C. acutus	6	—	1	5	6	51	—	3	1
Rhincalanus gigas	—	—	—	9	64	51	2	18	18
Clausocalanus laticeps	28	—	—	1	—	26	1	4	5
Ctenocalanus vanus	115	117	68	45	189	602	25	54	9
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	8	—	—	—
Pareuchaeta antarctica	1	—	—	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	8	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	—
M. lucens	300	—	34	—	—	56	2	—	1
Oithona frigida	467	945	1549	262	950	2265	89	523	427
Parathemisto gaudichaudi	—	—	—	—	—	—	—	—	—
Primno macropa	—	—	1	—	2	1	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus sp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Mysidae	—	—	—	—	—	—	—	—	—
Euphausia frigida, adult	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	1	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	1	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba, adult	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	55	11	66	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa macrura ♂	—	—	—	—	—	—	—	—	1
T. vicina ♂	2	—	—	—	3	1	—	—	1
Thysanoessa sp. ♀	—	8	—	—	2	—	—	1	1
Thysanoessa, cyrtopia	4	7	1	—	1	—	2	5	—
Thysanoessa, furcilia	—	2	—	—	—	—	1	—	—
Thysanoessa, calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	20	2	45	153	18	14	49	64	14
L. helicina	—	—	—	—	—	—	—	—	—
Limacina juv.	—	—	—	120	320	120	80	320	—
Salpa fusiformis	—	—	—	—	—	—	—	—	—
Appendicularia	—	1	—	—	195	25	—	—	—

* Exact position of these net hauls is unknown. They were taken between Sts. 111 and 112 but near 112 in fog whilst attempting to arrive at correct position for St. 112; sounding, however, showed that position was incorrect and ship proceeded further inshore taking up correct position for St. 112 when fog lifted.

Table II

Analyses of zooplankton samples collected in the closing N 70 H nets each towed for $\frac{1}{4}$ mile. Only the more important Copepoda and certain macroplankton animals are included, details of the occurrence of the less important species of Copepoda being given in the text. The hour figures for stations taken between sunset and sunrise are shown in heavy type. Full details of the meteorological and hydrological conditions will be found in the Station List, *Discovery Reports*, I, pp. 1–140.

Zooplankton Table II. *See foregoing explanation, p.* 413.

Station	**124**			**125**			**126**		
Date	18. xii. 26			18–19. xii. 26			19. xii. 26		
Hour	1838–1847			**0302–0317**			1214–1222		
Position	53° 45′ 30″ S, 36° 32′ 30″ W			53° 28′ 30″ S, 36° 20′ 30″ W			53° 58′ 30″ S, 37° 08′ W		
Sounding (m.)	220			3140			100		
Depth of nets (m.) ...	0–5	65	130	0–5	70	140	0–5	22	44(–0)
Calanus simillimus	1060	268	75	12	145	160	—	5	260
C. propinquus	192	72	30	40	96	400	—	23	520
C. acutus	—	92	655	2	—	40	—	1	40
Rhincalanus gigas	—	260	1,230	—	—	400	—	—	41
Clausocalanus laticeps	—	184	10	—	20	80	—	—	40
Ctenocalanus vanus	—	4,240	2,245	—	24	8,960	—	70	200
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	360	204	200	176	12	24	—	280	4,960
Pareuchaeta antarctica	—	1j	120	—	—	80	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	4	25	—	—	200	—	—	—
Pleuromamma robusta	—	—	5	—	—	—	—	—	—
Metridia gerlachei	—	—	240	—	—	640	—	—	—
M. lucens	—	—	—	—	—	—	—	—	—
Oithona frigida	460	51,472	17,360	—	48	37,800	18	1590	27,200
Parathemisto gaudichaudi	14j	16j	14j	2	—	4	—	—	4j
Euphausia spp. adult	—	—	2	—	—	—	—	—	—
Euphausia spp. immature	—	24	21	14	—	666	—	—	32
Salpa fusiformis	—	—	—	115	1	41	—	—	—

Station	**127**			**128**			**129**		
Date	19. xii. 26			19. xii. 26			19. xii. 26		
Hour	1530–1538			1844–1851			**2328–2339**		
Position	53° 48′ 30″ S, 37° 08′ W			53° 38′ 30″ S, 37° 08′ W			53° 28′ 30″ S, 37° 08′ W		
Sounding (m.)	157			167			1001		
Depth of nets (m.) ...	0–5	38	79	0–5	47	95	0–5	44	88(–0)
Calanus simillimus	—	24	107	6960	52	30	588	360	255
C. propinquus	8	9	158	8	5	356	16	1,200	200
C. acutus	—	3	164	—	—	—	—	520	320
Rhincalanus gigas	—	—	13	—	—	—	—	—	—
Clausocalanus laticeps	—	—	4	12	1	40	304	120	150
Ctenocalanus vanus	—	21	192	—	—	45	—	4,080	8,070
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	9	1256	732	1920	—	—	7	—	—
Pareuchaeta antarctica	—	—	14j	—	—	—	—	40	100
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	—	—	—	195
Pleuromamma robusta	—	—	—	—	—	—	1	200	195
Metridia gerlachei	—	—	—	—	—	—	—	560	140
M. lucens	—	—	—	—	—	—	8	120	115
Oithona frigida	20	434	420	—	3	102	—	13,920	119,540
Parathemisto gaudichaudi	—	—	7	—	9j	—	—	9	—
Euphausia spp. adult	2	158	476	—	6	—	1365	58	17
Euphausia spp. immature	—	1	6	—	1	61	214	520	849
Salpa fusiformis	—	—	—	9	—	74	253	520	141

j = juv.

Zooplankton Table II (*cont.*)

Station	**130**			**131**			**132**		
Date	20. xii. 26			20. xii. 26			20. xii. 26		
Hour	1159–1209			1522–1532			1839–1847		
Position	54° 06′ S, 36° 23′ W			53° 59′ 30″ S, 36° 11′ W			53° 52′ S, 35° 58′ 30″ W		
Sounding (m.)	122			240			180		
Depth of nets (m.) ...	0–5	37	75	0–5	62	124	0–5	45	90
Calanus simillimus	4	3	540	4	362	220	198	165	128
C. propinquus	1	4	84	—	88	140	36	69	77
C. acutus	—	—	72	—	50	100	—	—	3
Rhincalanus gigas	—	—	12	—	6	180	—	—	8
Clausocalanus laticeps	—	—	4	1	36	100	—	3	31
Ctenocalanus vanus	4	5	60	48	144	2740	58	13	—
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	3	248	11,520	—	—	—	24	4	12
Pareuchaeta antarctica	—	—	—	—	4j	11j	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	—
M. lucens	—	—	—	—	—	—	—	5	—
Oithona frigida	16	4100	304	720	10,676	9500	512	3	43
Parathemisto gaudichaudi	—	2j	1j	1j	—	—	55j	30j	—
Euphausia spp. adult	—	17	216	—	—	17	—	97	205
Euphausia spp. immature	3	—	23	—	74	27	12	52	—
Salpa fusiformis	—	1	—	—	—	—	—	99	64

Station	**133**			**134**			**135**		
Date	20–21. xii. 26			21. xii. 26			21. xii. 26		
Hour	0136–0154			1617–1630			1944–1959		
Position	53° 45′ 30″ S, 35° 46′ 30″ W			54° 22′ S, 35° 56′ W			54° 22′ S, 35° 39′ W		
Sounding (m.)	802			176			243		
Depth of nets (m.) ...	0–5	48	97	0–5	60	120	0–5	64	128
Calanus simillimus	845	14	4	8	429	80	124	1130	300
C. propinquus	830	13	19	20	72	40	2	130	40
C. acutus	180	4	1	—	21	400	—	32	40
Rhincalanus gigas	2	—	—	—	1	160	—	—	100
Clausocalanus laticeps	545	18	5	—	13	80	10	316	60
Ctenocalanus vanus	640	—	15	—	430	1,440	—	164	5,760
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	45	22	—	—	48	121,600	2484	88	720
Pareuchaeta antarctica	—	—	—	—	—	79j	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	5	3	—	—	—	—	—	—	—
M. lucens	—	—	—	—	—	40	—	—	—
Oithona frigida	24,640	262	82	25	7014	87,680	344	4652	387,520
Parathemisto gaudichaudi	281	2j	—	7j	2j	85j	3j	4j	98j
Euphausia spp. adult	51	—	—	1	22	—	—	57	—
Euphausia spp. immature	252	45	—	1	47	60	—	45	15
Salpa fusiformis	18	39	—	—	4	—	1	—	—

j = juv.

Zooplankton Table II (*cont.*)

Station	**136**			**137**			**138**		
Date	21. xii. 26			22. xii. 26			22. xii. 26		
Hour	**2317–2330**			0612–0626			1151–1205		
Position	54° 22′ S, 35° 21′ W			54° 19′ 30″ S, 35° 03′ 30″ W			54° 17′ S, 34° 47′ W		
Sounding (m.)	246			740			2530		
Depth of nets (m.) ...	0–5	48	96	0–5	60	120	0–5	74	148
Calanus simillimus	2773	248	25	68	114	80	—	100	16
C. propinquus	800	112	790	1	10	400	—	8, 420j	896
C. acutus	—	20	3,310	—	46	2,400	—	4,380	640
Rhincalanus gigas	—	—	70	—	—	560	—	4	188
Clausocalanus laticeps	320	196	105	3	30	560	—	720	44
Ctenocalanus vanus	—	52	10,560	95	—	14,960	—	960	2,176
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	48	—	552	100	—	—	—	—
Pareuchaeta antarctica	—	16j	100	—	—	80	—	—	80j
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	75	—	—	—	—	—	120
Pleuromamma robusta	—	20	230	—	4	—	—	—	—
Metridia gerlachei	—	440	655	—	8	2	—	—	8
M. lucens	—	384	790	2	4	—	—	—	—
Oithona frigida	—	48,100	77,500	252	1772	68,000	248	1,418,480	12,624
Parathemisto gaudichaudi	477	1, 20j	—	—	1, 13j	12	—	12j	1, 37j
Euphausia spp. adult	7813	—	—	1	27	106	1	3	—
Euphausia spp. immature	8	273	856	—	—	240	—	1,740	318
Salpa fusiformis	205	128	15	1	15	10	—	1	4

Station	**139**			**151**			**160**		
Date	22–23. xii. 26			16. i. 27			7. ii. 27		
Hour	**0116–0126**			1329–1340			1602–1613		
Position	53° 30′ 15″ S, 35° 50′ 45″ W			53° 25′ S, 35° 15′ W			Near Shag Rocks, 53° 43′ 40″ S, 40° 57′ W		
Sounding (m.)	3230			3200			177		
Depth of nets (m.) ...	0–5	62	124	0–5	66	132	0–5	42	84
Calanus simillimus	320	26	5	—	—	—	—	—	—
C. propinquus	76	183	2	—	—	4j	—	3j	—
C. acutus	—	—	—	—	—	1	—	—	—
Rhincalanus gigas	—	—	1	—	—	—	—	—	—
Clausocalanus laticeps	360	130	1	—	—	12	—	—	—
Ctenocalanus vanus	60	500	18	—	—	8	—	—	—
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	32j	—	—	—	40j	—	—	—	—
Pareuchaeta antarctica	—	—	1j	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	—
M. lucens	—	3	6	—	—	—	—	—	—
Oithona frigida	560	390	124	—	510	160	—	—	—
Parathemisto gaudichaudi	2, 85j	14	1	—	—	6	—	1	—
Euphausia spp. adult	26	111	11	—	—	—	—	—	—
Euphausia spp. immature	48	36	4	—	2300	36	—	3	—
Salpa fusiformis	31	510	53	—	—	188	—	—	—

j = juv.

Zooplankton Table II (*cont.*)

Station	**161**			**WS 18**			**WS 19**		
Date	14. ii. 27			26. xi. 26			27. xi. 26		
Hour	1235–1243			1944–**2023**			1425–1439		
Position	57° 21′ 20″ S, 46° 43′ 30″ W			54° 07′ S, 36° 23′ W			54° 00′ 30″ S, 36° 20′ 30″ W		
Sounding (m.)	3459			113			128		
Depth of nets (m.) ...	0–5	40	80	0–5	46	128	0–5	62	155
Calanus simillimus	—	—	—	92	100	100	144	14	180
C. propinquus	—	—	—	66	80	40	16	20	180
C. acutus	—	—	—	109	1,080	720	384	21	140
Rhincalanus gigas	—	—	—	3	20	130	—	153	560
Clausocalanus laticeps	—	—	—	—	80	30	8	—	—
Ctenocalanus vanus	—	—	—	624	6,380	960	168	14	80
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	—	—	674	4,960	480	496	544	680
Pareuchaeta antarctica	—	—	—	—	4j	90j	—	—	60j
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	—	—	—	1
Pleuromamma robusta	—	—	—	—	—	1	—	—	—
Metridia gerlachei	—	—	—	—	2	10	—	—	20
M. lucens	—	—	—	1	—	—	—	—	—
Oithona frigida	—	—	—	2924	14,960	13,400	4128	252	2780
Parathemisto gaudichaudi	—	—	—	—	—	—	—	—	—
Euphausia spp. adult	—	—	—	—	—	—	—	—	—
Euphausia spp. immature	—	—	—	—	13	6	—	4	—
Salpa fusiformis	—	—	—	7	—	2	—	—	—

Station	**WS 20**			**WS 21**			**WS 22**		
Date	28. xi. 26			28. xi. 26			30. xi. 26		
Hour	1155–1238			1710–1750			**2007–2022**		
Position	53° 52′ 30″ S, 36° 00′ W			53° 45′ 30″ S, 35° 48′ W			53° 38′ S, 35° 35′ W		
Sounding (m.)	535			899			2260		
Depth of nets (m.) ...	0–5	71	164	0–5	90	192	0–5	71	165
Calanus simillimus	36	32	72	48	140	8	3835	166	300
C. propinquus	21	16	7	73	40	26	11	8, 6j	40
C. acutus	60	88	152	—	260	40	4	109	260
Rhincalanus gigas	—	56	112	—	300	15	1	—	80
Clausocalanus laticeps	—	2	3	24	27	8	5	39	60
Ctenocalanus vanus	—	832	64	8	1,900	128	15	1438	990
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	500
Drepanopus pectinatus	62	160	9	—	—	32	4550	1	800
Pareuchaeta antarctica	—	—	23j	—	6j	5j	2j	12j	60j
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	39	—	—	—	—	2	60
Pleuromamma robusta	—	—	—	—	—	1	—	—	—
Metridia gerlachei	—	—	9	—	—	1	5	—	360
M. lucens	—	—	15	—	—	—	—	—	200
Oithona frigida	30	3936	1160	24	30,000	15,108	—	5756	23,800
Parathemisto gaudichaudi	—	—	—	—	—	—	1, 274j	2j	—
Euphausia spp. adult	—	—	1	—	—	—	—	—	—
Euphausia spp. immature	3	18	19	1	134	25	12	10	74
Salpa fusiformis	3	—	33	1	2	1	22	1	38

j=juv.

Zooplankton Table II (*cont.*)

Station	**WS 24**			**WS 26**			**WS 27**	
Date	10. xii. 26			18. xii. 26			19. xii. 26	
Hour	1746–1754			**0003–0010**			0842–0850	
Position	54° 12′ 07″ S, 36° 28′ 07″ W			53° 33′ 15″ S, 37° 45′ 15″ W			53° 55′ S, 38° 01′ W	
Sounding (m.)	172–212			1180			80	
Depth of nets (m.) ...	0–5	58	117	0–5	70·4	140	0–5	104
Calanus simillimus	554	—	242	—	12	255	2	40
C. propinquus	30	—	61	1	12	295	18	32
C. acutus	—	—	60	—	—	205	—	16
Rhincalanus gigas	3	—	300	—	—	1,575	—	388
Clausocalanus laticeps	1	—	1	—	24	10	—	—
Ctenocalanus vanus	44	—	1,500	—	624	3,910	4	2,112
Microcalanus pygmaeus	—	—	—	—	—	—	—	—
Drepanopus pectinatus	30	—	36,060	—	564	195	39	3,456
Pareuchaeta antarctica	—	—	2j	—	4j	115, 56j	—	6j
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	250	—	12
Pleuromamma robusta	—	—	—	—	8	235	—	8
Metridia gerlachei	—	—	—	—	28	305	—	16
M. lucens	—	—	—	—	—	75	—	—
Oithona frigida	9	—	31,220	—	572	113,430	52	31,352
Parathemisto gaudichaudi	—	—	—	2, 4j	5j	30j	—	26j
Euphausia spp. adult	—	—	—	547	31	—	1	3
Euphausia spp. immature	10	—	8	—	14	273	—	8
Salpa fusiformis	—	—	—	—	49	5	—	—

Station	**WS 28**		**WS 29**			**WS 30**		
Date	19. xii. 26		19. xii. 26			19–20. xii. 26		
Hour	1202–1210		1700–1708			**0012–0019**		
Position	53° 48′ 15″ S, 38° 13′ W		53° 41′ 15″ S, 38° 24′ 45″ W			53° 34′ 15″ S, 38° 36′ 15″ W		
Sounding (m.)	150–346		614			2582		
Depth of nets (m.) ...	0–5	88	0–5	66	131	0–5	100–5	105
Calanus simillimus	—	100	16	13	100	3220	38	218
C. propinquus	7	34	3	5	360	800	1	61
C. acutus	2	12	—	—	—	260	—	1,380
Rhincalanus gigas	—	141	—	8	180	—	—	780
Clausocalanus laticeps	—	12	—	1	40	120	21	—
Ctenocalanus vanus	—	256	—	32	960	160	—	14,940
Microcalanus pygmaeus	—	—	—	—	—	—	—	—
Drepanopus pectinatus	10	—	1	6	60	6480	—	—
Pareuchaeta antarctica	—	2j	—	—	—	—	2, 2j	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	—	12	—
Pleuromamma robusta	—	—	—	—	—	—	—	60
Metridia gerlachei	—	—	—	—	20	—	—	240
M. lucens	—	6	—	—	—	60	—	120
Oithona frigida	12	19,340	8	400	6480	—	—	61,600
Parathemisto gaudichaudi	—	7j	—	—	6j	86j	—	—
Euphausia spp. adult	—	2	—	—	1	1227	—	—
Euphausia spp. immature	—	6	1	2	17	7	144	—
Salpa fusiformis	—	14	—	4	145	96	127	—

j = juv.

Zooplankton Table II (*cont.*)

Station	**WS 31**		**WS 33**		**WS 34**		**WS 35**		
Date	20. xii. 26		21. xii. 26		21. xii. 26		21–22. xii. 26		
Hour	1734–1742		1752–1800		**2057–2105**		**0255–0303**		
Position	54° 52′ S, 35° 36′ W		54° 59′ S 35° 24′ W		55° 06′ S, 35° 11′ W		55° 13′ 15″ S, 34° 59′ W		
Sounding (m.)	76		135		121		161		
Depth of nets (m.) ...	0–5	56·6	0–5	97	0–5	80·5	0–5	65·3	131·6
Calanus simillimus	756	1008	718	—	900	12	200	320	255
C. propinquus	32	24	22	—	420	32j	36	220	160
C. acutus	4	256	6j	75	2,840	896	400	1,760	2,680
Rhincalanus gigas	—	—	—	240	—	16	—	100	110
Clausocalanus laticeps	—	160	13	240	—	8	4	440	130
Ctenocalanus vanus	16	65	40	—	—	256	208	960	3,920
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	1576	184j	193, 672j	142,800	46,080	48,192	1,608	1,000	1,730
Pareuchaeta antarctica	—	—	—	—	—	4j	—	—	38j
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	—	—	—	10
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	20	25
M. lucens	—	—	—	—	90	12	—	—	—
Oithona frigida	8	240	706	3,120	24,450	4,824	10,056	45,840	64,920
Parathemisto gaudichaudi	21j	28j	4j	—	1,110j	—	28j	30j	6j
Euphausia spp. adult	—	1	—	2	—	—	—	—	—
Euphausia spp. immature	2	29	3	30	513	136	24	542	829
Salpa fusiformis	—	1	—	—	—	—	—	14	—

Station	**WS 36**			**WS 37**			**WS 38**		
Date	22. xii. 26			22. xii. 26			22–23. xii. 26		
Hour	0832–0840			1725–1733			0348–0413		
Position	55° 20′ 15″ S, 34° 46′ 30″ W			54° 45′ S, 35° 11′ W			54° 01′ S, 35° 14′ W		
Sounding (m.)	1242			318			2103		
Depth of nets (m.) ...	0–5	67	135	0–5	64	128	0–5	59	118
Calanus simillimus	68	59	160	8	150	498	24	8	180
C. propinquus	12	7	46, 865j	—	12	36	—	—	66
C. acutus	198	39	5,600	—	—	164	—	—	300
Rhincalanus gigas	—	15	37	—	—	108	—	—	15
Clausocalanus laticeps	8	4	185	—	3	79	8	4	102
Ctenocalanus vanus	160	52	2,300	—	48	510	—	12	1,872
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	268	332j	200	3	24	50	1200j	6	—
Pareuchaeta antarctica	—	—	9j	—	—	1j	—	—	11j
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	10	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	1	—	—	—	—	—	—
M. lucens	—	2	—	—	—	—	—	—	—
Oithona frigida	15,364	1910	139,130	57	540	23,100	72	48	48,540
Parathemisto gaudichaudi	9j	3	—	—	3j	46j	—	3j	15j
Euphausia spp. adult	—	—	68	—	—	19	—	—	9
Euphausia spp. immature	4	344	1,310	—	26	160	1	3	345
Salpa fusiformis	—	29	3	—	1	21	14	—	74

j = juv.

Zooplankton Table II (*cont.*)

Station	**WS 39**			**WS 40**			**WS 41**	
Date	23. xii. 26			7. i. 27			7. i. 27	
Hour	0821–0829			0908–0916			1604–1612	
Position	54° 08′ S, 35° 43′ W			55° 09′ S, 35° 58′ W			54° 32′ 45″ S, 36° 43′ 45″ W	
Sounding (m.)	237			183			140	
Depth of nets (m.) ...	0–5	59	117	0–5	54	108	0–5	55
Calanus simillimus	—	4	1,104	—	20	25	2	68
C. propinquus	—	6	352	—	100j	260j	—	14
C. acutus	—	2	208	—	800	1,275	—	220
Rhincalanus gigas	—	—	220	—	380	200	—	24
Clausocalanus laticeps	—	5	280	—	—	130	—	30
Ctenocalanus vanus	—	64	2,112	—	1,200	4,135	—	288
Microcalanus pygmaeus	—	—	—	—	—	—	—	—
Drepanopus pectinatus	1	52	24	—	—	115	168	1292
Pareuchaeta antarctica	—	—	—	—	—	6j	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	40	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—
M. lucens	1j	—	—	—	—	10	—	—
Oithona frigida	6	266	41,188	—	22,060	30,355	20,800	4276
Parathemisto gaudichaudi	1j	—	25j	—	28	1	—	1
Euphausia spp. adult	—	1	8	—	—	—	—	—
Euphausia spp. immature	—	24	392	—	1,460	186	1	64
Salpa fusiformis	3	—	3	—	—	—	—	—

Station	**WS 42**			**WS 43**			**WS 44**		
Date	7. i. 27			7–8. i. 27			8. i. 27		
Hour	**2104–2112**			**0053–0133**			0934–0942		
Position	54° 41′ 45″ S, 36° 47′ W			54° 54′ S, 36° 50′ W			55° 06′ S, 36° 57′ W		
Sounding (m.)	175			200			1470		
Depth of nets (m.) ...	0–5	55	110	0–5	62	124	0–5	79	159
Calanus simillimus	6,400	85	30	259	10	20	—	12	Sample lost
C. propinquus	5,600	615	130j	133j	10	20	—	—	
C. acutus	1,600	1,345	630	980	120	280	—	192	
Rhincalanus gigas	—	5	15	7	8	20	—	16	
Clausocalanus laticeps	—	10	5	420	10	80	—	4	
Ctenocalanus vanus	—	1,120	560	6,260	520	3,600	—	—	
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	
Drepanopus pectinatus	2,240,000	495	1,810	385	20	20	—	—	
Pareuchaeta antarctica	—	1, 25j	50j	—	2j	11	—	—	
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	
Scolecithricella minor	—	—	5	—	50	60	—	2	
Pleuromamma robusta	—	—	—	—	—	—	—	—	
Metridia gerlachei	—	—	75	126	10	—	—	—	
M. lucens	—	—	190	686	50	140	—	3	
Oithona frigida	—	68,640	10,350	63,648	7380	284,800	—	37,500	
Parathemisto gaudichaudi	—	61	2	5	1j	—	—	11	
Euphausia spp. adult	—	—	—	—	1	—	—	—	
Euphausia spp. immature	220	218	20	—	20	66	1	91	
Salpa fusiformis	—	—	4	3	—	—	—	18	

j = juv.

Zooplankton Table II (*cont.*)

Station	**WS 45**			**WS 46**			**WS 47**		
Date	8. i. 27			8. i. 27			9. i. 27		
Hour	1856–1904			2356–0004			0338–0346		
Position	54° 38′ 30″ S, 37° 30′ 55″ W			54° 20′ 15″ S, 37° 32′ 30″ W			54° 22′ S, 37° 50′ W		
Sounding (m.)	180			194			160		
Depth of nets (m.) ...	0–5	53	106	0 ·5	87	174	0–5	39	77
Calanus simillimus	400	80	40	56	1,276	20	880	175	56
C. propinquus	2	240	100	252	184j	40	20	60j	320
C. acutus	1,100	2,240	1,120	116	24	500	52	330	2,496
Rhincalanus gigas	—	80	40	3	60	40	—	5	16
Clausocalanus laticeps	—	—	40	120	16	80	—	85	20
Ctenocalanus vanus	—	5,840	3,840	816	2,848	1240	—	1,060	1,736
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	40,300	640j	260	5,768	192	120	80,160, 431,520j	44,940	47,264
Pareuchaeta antarctica	—	—	3j	30j	24j	3, 80j	—	4j	16
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	20	—	12	40	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	28	—	—	—	—
M. lucens	—	—	—	336	8	100	—	5j	—
Oithona frigida	40	71,660	190,240	30,584	33,856	8240	—	10,620	76,624
Parathemisto gaudichaudi	1	5	4j	—	—	1	4	17	6
Euphausia spp. adult	—	—	—	—	—	—	—	—	—
Euphausia spp. immature	—	365	—	94	184	196	4	33	111
Salpa fusiformis	—	—	—	—	19	—	—	—	1

Station	**WS 48**			**WS 49**			**WS 50**		
Date	9. i. 27			9. i. 27			9. i. 27		
Hour	0707–0715			1023–1031			1427–1435		
Position	54° 24′ S, 38° 09′ W			54° 28′ S, 38° 22′ 15″ W			54° 30′ 30″ S, 38° 40′ 30″ W		
Sounding (m.)	224			223			230		
Depth of nets (m.) ...	0–5	100	200	0–5	80	161	0–5	82	164
Calanus simillimus	132	20	20	6	40	40	—	28	30
C. propinquus	66	40	12	—	20	280	—	46	14
C. acutus	144	120	164	2	720	120	—	52	6
Rhincalanus gigas	—	—	—	—	120	52	1	14	50
Clausocalanus laticeps	—	—	—	4	40	80	—	—	6
Ctenocalanus vanus	318	480	84	12	1600	200	—	160	48
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	20,646	23,840	7312	312, 2062j	60	43,560	2	8	216
Pareuchaeta antarctica	—	—	2, 29j	—	—	1	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	8	—	—	—	—	—	—
Pleuromamma robusta	—	—	4	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	—
M. lucens	—	—	16	—	—	—	—	—	—
Oithona frigida	2,984	6,640	1060	587	4040	2,580	160	1408	6890
Parathemisto gaudichaudi	4	—	—	—	1j	—	—	—	—
Euphausia spp. adult	—	—	—	—	—	—	—	—	—
Euphausia spp. immature	—	22	35	4	19	19	1	6	49
Salpa fusiformis	—	—	—	—	—	16	—	—	1

j = juv.

Zooplankton Table II (*cont.*)

Station	**WS 51**			**WS 52**			**WS 54**	
Date	9. i. 27			10. i. 27			12. i. 27	
Hour	1744–1752			0922–0930			0751–0759	
Position	54° 34′ S, 38° 57′ W			54° 03′ 30″ S, 38° 35′ W			53° 29′ S, 37° 13′ 45″ W	
Sounding (m.)	210			184			2281	
Depth of nets (m.) ...	0–5	58	119	0–5	54	108	0–5	70
Calanus simillimus	—	1	—	—	—	60	—	8
C. propinquus	—	—	—	1	1	33	—	5
C. acutus	—	—	120	—	4	39	—	—
Rhincalanus gigas	—	—	38	—	3	318	—	—
Clausocalanus laticeps	—	—	—	—	—	9	—	2
Ctenocalanus vanus	—	—	—	—	20	33	—	—
Microcalanus pygmaeus	—	—	—	—	—	—	—	—
Drepanopus pectinatus	850	28	—	4	—	18	—	—
Pareuchaeta antarctica	—	—	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	—	—	—	6	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—
M. lucens	—	—	—	—	—	—	—	—
Oithona frigida	240	41	—	512	760	7340	12	120
Parathemisto gaudichaudi	1j	—	1	—	6j	17j	1j	1
Euphausia spp. adult	—	—	—	—	—	—	—	—
Euphausia spp. immature	—	—	7	1	2	25	1	264
Salpa fusiformis	—	—	—	—	—	—	1	—

Station	**WS 60**	**WS 61**			**WS 63**		
Date	17. i. 27	18. i. 27			20–21. i. 27		
Hour	**2220–2345**	**0157–0205**			**0006–0014**		
Position	52° 47′ S, 37° 06′ 30″ W	52° 37′ 30″ S, 37° 06′ 30″ W			54° 36′ S, 39° 14′ W		
Sounding (m.)	—	1892–2201			1752		
Depth of nets (m.) ...	50–0	0–5	80	159	0–5	80	161
Calanus simillimus	24	6	1	—	480	—	14
C. propinquus	1128	140	24	—	1120	4	82
C. acutus	8	—	8	—	40	20	1052
Rhincalanus gigas	—	—	—	—	—	1	8
Clausocalanus laticeps	8	36	10	—	920	2	26
Ctenocalanus vanus	88	1220	40	—	6800	12	1360
Microcalanus pygmaeus	—	—	—	—	—	—	—
Drepanopus pectinatus	8	—	—	—	—	—	64
Pareuchaeta antarctica	16	—	6j	2j	—	1	36j
Pareuchaeta sp. juv.	—	—	—	—	—	—	—
Scolecithricella minor	—	—	6	—	—	—	46
Pleuromamma robusta	—	—	—	5	—	—	10
Metridia gerlachei	16	—	—	—	—	—	—
M. lucens	136	5	104	—	1160	4	28
Oithona frigida	—	25	5200	—	4080	40	9736
Parathemisto gaudichaudi	12	5	1	—	112	—	—
Euphausia spp. adult	1182	1	—	11	69	—	—
Euphausia spp. immature	87	132	82	—	800	7	63
Salpa fusiformis	219	—	3	—	50	9	1

j = juv.

Zooplankton Table II (*cont.*)

Station	**WS 67**			**WS 68**			**WS 69**		
Date	20. ii. 27			21. ii. 27			22. ii. 27		
Hour	1240–1248			0722–0731			**0344–0356**		
Position	53° 19′ S, 45° 16′ W			52° 53′ S, 48° 48′ W			52° 19′ S, 52° 11′ W		
Sounding (m.)	1839			3197			2743		
Depth of nets (m.) ...	0–5	66	132	0–5	66	132	0–5	55	110
Calanus simillimus	—	1,060j	400j	600j	5,680j	4,080	—	3,840	125
C. propinquus	—	—	—	—	—	—	290	—	—
C. acutus	—	40	40	—	80	40	—	—	2
Rhincalanus gigas	—	20j	80	—	20	60	—	280j	1, 12j
Clausocalanus laticeps	—	2	60	1,200j	120j	120	600	320	12
Ctenocalanus vanus	—	—	380	—	20	580	240	19,200	56
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	27j
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—
Pareuchaeta sp. juv.	—	—	—	—	—	20	—	—	—
Scolecithricella minor	—	—	80	—	—	40	—	—	2
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Metridia gerlachei	—	—	—	—	—	—	—	—	—
M. lucens	—	—	820j	—	—	320	—	280	12
Oithona frigida	20	81,760	59,240	24,000	38,460	14,880	1640	6,400	60
Parathemisto gaudichaudi	—	—	1	24j	1	1	2, 90j	8	—
Euphausia spp. adult	—	—	—	—	—	—	—	—	—
Euphausia spp. immature	—	375	80	2	52	30	5	1,480	3
Salpa fusiformis	—	—	—	—	—	—	8	169	—

Station	**WS 70**			**WS 110**			**WS 111**		
Date	22–23. ii. 27			26. v. 27			26–27. v. 27		
Hour	**0141–0149**			**1741–1749**			**2049–2057**		
Position	51° 58′ S, 55° 42′ W			53° 46′ S, 35° 47′ W			53° 39′ S, 35° 34′ W		
Sounding (m.)	—			988			1500		
Depth of nets (m.) ...	0–5	86	172	0–5	62	124	0–5	42	84
Calanus simillimus	—	3360j	120	144	200	—	—	8	60
C. propinquus	—	—	2080	24	320	—	—	32	140
C. acutus	—	—	—	160	20	—	—	8	20
Rhincalanus gigas	—	200j	160j	16	—	—	—	—	—
Clausocalanus laticeps	960	180	80	56	100	—	—	56	60
Ctenocalanus vanus	9,600	1120	800	1,024	7,940	23	—	80	3,000
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	—	—	16	80	—	—	—	—
Pareuchaeta antarctica	—	—	3, 240j	—	—	—	—	1, 8j	26j
Pareuchaeta sp. juv.	—	45	—	—	—	—	—	—	—
Scolecithricella minor	—	120	160	—	—	—	—	8	40
Pleuromamma robusta	—	—	80	—	—	—	—	—	40
Metridia gerlachei	—	—	—	—	—	—	—	—	60
M. lucens	1	1200	1120	24	320	5	—	16	100
Oithona frigida	15,360	1550	1280	16,576	27,260	168	—	1420	22,600
Parathemisto gaudichaudi	—	—	—	—	—	—	—	1	—
Euphausia spp. adult	—	—	171	2	—	—	—	—	—
Euphausia spp. immature	—	328	40	76	138	—	—	176	293
Salpa fusiformis	119	69	9	—	—	—	—	—	—

j = juv.

Zooplankton Table II (*cont.*)

Station	**WS 112**			**WS 113**			**WS 114**		
Date	27. v. 27			28. v. 27			28. v. 27		
Hour	1322–1329			1103–1111			1411–1419		
Position	53° 54′ 30″ S, 36° 06′ W			54° 07′ S, 36° 24′ W			54° 00′ S, 36° 12′ W		
Sounding (m.)	155			155			163		
Depth of nets (m.) ...	0–5	77	154	0–5	31	62	0–5	58	116
Calanus simillimus	18	101	23	—	3	1	3	7	30
C. propinquus	2	6	22	—	4	2	—	—	26
C. acutus	—	—	16	1	6	20	—	1	6
Rhincalanus gigas	2	5	88	1	—	27	1	2	62
Clausocalanus laticeps	4	—	17	1	—	6	6	10	8
Ctenocalanus vanus	250	—	256	101	400	—	560	126	716
Microcalanus pygmaeus	—	—	—	—	—	—	—	—	—
Drepanopus pectinatus	—	—	—	—	—	—	—	—	1
Pareuchaeta antarctica	—	—	6	—	1	—	—	—	1j
Pareuchaeta sp. juv.	—	—	—	—	—	—	—	—	—
Scolecithricella minor	—	—	9	—	—	—	—	—	—
Pleuromamma robusta	—	1	—	—	—	—	—	—	—
Metridia gerlachei	—	—	25	—	—	2	—	—	—
M. lucens	—	—	30	—	—	—	—	—	—
Oithona frigida	11,890	3190	10,804	29,300	51,600	21,100	17,140	2071	14,812
Parathemisto gaudichaudi	—	—	—	—	—	1	—	5	—
Euphausia spp. adult	—	—	—	—	—	—	—	—	—
Euphausia spp. immature	37	12	14	—	21	—	—	7	108
Salpa fusiformis	—	—	—	—	—	—	—	—	—

j = juv.

Table III

Analyses of zooplankton samples collected in the closing N 100 H nets, each towed for 1 mile *except at Stations* 31–38 *where distance was* 3 *miles*. The hour figures for stations taken between sunset and sunrise are shown in heavy type. Full details of the meteorological and hydrological conditions will be found in the Station List, *Discovery Reports*, I, pp. 1–140. The consecutive net series of hauls at Sts. 150 and WS 53 are shown in Tables IV and V of this Appendix.

Zooplankton Table III. *See foregoing explanation, p.* 425.

Station	**8**		**23**		**24**		**25**	
Date	8. ii. 26		14. iii. 26		14. iii. 26		14. iii. 26	
Hour	1520–1625		1305–1320		1600–1700		**1825–1935**	
Position	42° 36′ 30″ S, 18° 19′ 30″ W		5·3 miles N 44° E of Merton Rock, S. Georgia		10 miles N 72° E of Jason Lt, S. Georgia		18 miles N 60° E of Jason Lt, S. Georgia	
Sounding (m.)	3375		228		—		—	
Depth of nets (m.) ...	0–10	0	0	60(–0)	0	60(–0)	0–5	60(–0)
Medusae	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	36	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	1	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	2	—
Calanus simillimus	—	—	—	—	—	—	—	—
C. propinquus	140	—	—	—	—	148j	1	792
C. acutus	18	—	—	1	—	1j	—	—
Rhincalanus gigas	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	36	2	—	347	—	179	1800	1400
Primno macropa	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	1	—	—
Cyllopus spp.	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	4	3
Antarctomysis maxima	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	—	—	}3070*	28*	5
E. superba ♀	—	—	—	—	—			8
E. superba, immature	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	28	—	—	58	—	1	4	—
T. vicina ♀	22	—	—	170	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	7
T. macrura ♀	—	—	—	2	—	9	14	26
Thysanoessa spp.	2	—	—	—	—	—	44	10
Thysanoessa spp. immature	—	—	—	—	—	3206	—	—
Thysanoessa spp. cyrtopia	—	—	—	28	—	—	4	6208
Thysanoessa spp. furcilia	1	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—
Limacina balèa	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—
Spongiobranchaea australis	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	—	—
Oikopleura	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	—	—	—	—

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**26**		**31**			**32**		
Date	14. iii. 26		17. iii. 26			17. iii. 26		
Hour	**2045–2125**		**1910–2045**			**2300–2358**		
Position	26·5 miles N 54° E of Jason Lt, S. Georgia		13·5 miles N 89° E of Jason Lt, S. Georgia			22·8 miles N 70½° E of Jason Lt, S. Georgia		
Sounding (m.)	—		220			—		
Depth of nets (m.) ...	0–5	60(–0)	0–5	50(–0)	90(–0)	0–5	50(–0)	90(–0)
Medusae	—	—	—	—	—	—	—	—
Beroë	—	—	200	10	4	15	—	50
Ctenophora, *alia*	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	9	2	—	—	32	—	—	—
Tomopteris spp.	—	1	—	—	—	—	—	—
Calanus simillimus	—	—	—	—	4	—	—	—
C. propinquus	—	2, 2474j	—	432	480	—	12, 240j	13, 214j
C. acutus	—	272	—	—	212	—	—	12j
Rhincalanus gigas	—	—	—	32	100	—	—	3, 3j
Pareuchaeta antarctica	1j	768, 704j	—	—	2	—	—	4, 8j
Pleuromamma robusta	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	4000	694	3850	372	400	11,000	264	722
Primno macropa	—	—	—	—	—	—	—	—
Vibilia antarctica	—	10	—	—	—	—	—	—
Cyllopus spp.	—	—	—	—	1	—	9	13
Amphipoda, *alia*	31	13	13	—	—	203	3	4
Antarctomysis maxima	—	—	—	7	122	—	—	3
Euphausia frigida ♂	6	778	—	202	211	—	6	301
E. frigida ♀	30	3687	—	284	475	—	12	342
E. frigida, immature	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	264	—	81	—	—	—	—
E. frigida, furcilia	—	2172	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—
E. superba ♂	—	2*	623*	3069*	113*	61*	1208*	313*
E. superba ♀	—							
E. superba, immature	—	—	—	—	—	—	—	—
E. superba, cyrtopia	2	721	—	20	29	—	—	—
E. superba, furcilia	2	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	2001	—	801	346	—	—	208
T. vicina ♀	—	3681	—	902	190	—	—	—
T. macrura ♂	—	—	—	3	—	—	—	—
T. macrura ♀	—	1	—	16	—	—	—	419
Thysanoessa spp.	—	—	—	—	—	—	780	—
Thysanoessa spp. immature	—	—	—	—	—	—	—	42
Thysanoessa spp. cyrtopia	—	1340	—	2	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	4	1
L. helicina	—	—	—	—	—	—	—	—
Spongiobranchaea australis	—	—	—	—	—	1	—	—
Salpa fusiformis	2	2	—	—	—	—	—	—
Oikopleura	—	—	—	—	—	—	—	—
Fish juv.	—	—	3	6	3	1	—	1

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**33**			**34**			**35**		
Date	18. iii. 26			18. iii. 26			18. iii. 26		
Hour	0945–1040			1225–1335			1505–1620		
Position	33 miles N 37° E of Jason Lt, S. Georgia			43 miles N 39° E of Jason Lt, S. Georgia			53 miles N 40° E of Jason Lt, S. Georgia		
Sounding (m.)	—			—			—		
Depth of nets (m.) ...	0–5	50(–0)	90(–0)	0	50(–0)	90(–0)	0	50(–0)	90(–0)
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—
Calanus simillimus	—	—	—	—	—	—	—	—	—
C. propinquus	—	—	9	—	—	—	—	—	32
C. acutus	—	—	—	—	—	—	—	—	—
Rhincalanus gigas	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	—	580	227	—	210	420	—	75	400
Primno macropa	—	—	4, 1j	—	—	—	—	—	4
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus spp.	—	—	—	—	—	—	—	—	2
Amphipoda, *alia*	—	—	—	—	7	5	—	5	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	—	—	—	—	—	—
E. superba ♀	—	—	—	—	—	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	131	—	—	—	—	—	382
T. vicina ♀	—	—	489	—	—	—	—	—	2861
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	—	—	—	—	—	—	—	—
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	—	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	—	—	—	—	—

j = juv.

Zooplankton Table III (*cont.*)

Station	36			37			38		
Date	18. iii. 26			18–19. iii. 26			19. iii. 26		
Hour	**2010–2150**			**0005–0120**			**0355–0505**		
Position	38 miles N 39° E of Jason Lt, S. Georgia			28 miles N 36° E of Jason Lt, S. Georgia			18·5 miles N 33° E of Jason Lt, S. Georgia		
Sounding (m.)	—			—			—		
Depth of nets (m.) ...	0–5	50(–0)	90(–0)	5–0	50(–0)	90(–0)	0–5	50(–0)	90(–0)
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	34	—	2
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	22	—	14	12	8	33	—	—	2
Tomopteris spp.	1	1	2	—	—	17	2	—	—
Calanus simillimus	—	—	—	—	—	—	—	—	5
C. propinquus	1, 8j	12, 136j	7, 80j	—	112, 224j	16, 64j	—	—	30, 93j
C. acutus	—	—	8	—	—	—	—	—	36
Rhincalanus gigas	—	—	16j	—	—	—	—	—	52
Pareuchaeta antarctica	14j	16, 92j	37, 178j	512, 5184j	211, 1936j	129, 1421j	—	—	—
Pleuromamma robusta	—	20	25	—	—	58	—	—	—
Parathemisto gaudichaudi	2000	163	118	1936	505	152	13,300	200	359
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	4	4	64	—	—	—	—	—
Cyllopus spp.	3	—	—	9	4	24	—	—	—
Amphipoda, *alia*	3	—	—	—	2	18	5	—	2
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	169	528	91	1903	552	237	—	—	2
E. frigida ♀	462	582	243	5406	1104	1194	—	—	30
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	76	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	9*	3*	—	3*	—	—	5,316*	5400*	81*
E. superba ♀									
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	6	1591	—	148	—	—	—
E. superba, furcilia	—	54	45	152	—	—	—	—	2
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	140	1186	160	—	337	960	—	—	414
T. vicina ♀	173	4690	514	—	455	3040	—	—	445
T. macrura ♂	—	—	—	152	—	1*	—	—	56
T. macrura ♀	—	—	—	—	—		—	—	66
Thysanoessa spp.	—	—	—	—	—	—	—	—	—
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	8	—	21	—	—	—	—	—	62
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	44	2	176	7	3	—	—	1
L. helicina	—	—	—	—	—	—	—	—	—
Spongiobranchaea australis	—	—	1	—	1	—	—	—	3
Salpa fusiformis	1	—	—	8	3	5	—	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	—	2	—	—	—

* Sex not determined. j=juv.

Zooplankton Table III (*cont.*)

Station	**40**			**41**			**43**		
Date	28. iii. 26			28. iii. 26			3. iv. 26		
Hour	1000–1018			1112–1135			1338–1445		
Position	7 miles N 39° E of Barff Pt, S. Georgia			16½ miles N 39° E of Barff Pt, S. Georgia			15 miles N 58° E of Jason Lt, S. Georgia		
Sounding (m.)	—			272			—		
Depth of nets (m.) ...	0–5	50(–0)	90(–0)	0–5	50(–0)	90(–0)	0–5	75(–0)	150(–0)
Medusae	—	—	—	—	—	—	—	—	—
Beroë	36	24	6	21	2	2	20	—	3
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	7	—	64
Tomopteris spp.	—	—	—	3	—	—	—	—	—
Calanus simillimus	—	—	—	—	—	—	—	—	—
C. propinquus	—	—	30	5	4	45j	13	—	75
C. acutus	—	—	830	11	6	120j	1	—	60
Rhincalanus gigas	—	—	6	—	—	15j	2	—	75
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	34, 21j	191	1050	190	117	33	50j	200j	62
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus spp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	1	—	1	1	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	317*	38*	60*	1916*	64*	157*	210*	4*	2*
E. superba ♀									
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	2272	29	—	208	33	6	—	—
T. vicina ♀	—	2272	38	—	285	166	31	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	1	—	—	—
Thysanoessa spp.	218	—	—	—	—	—	—	19	234
Thysanoessa spp. immature	—	6528	—	880	—	—	—	—	16
Thysanoessa spp. cyrtopia	—	—	6	—	19	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	23
L. helicina	—	—	—	—	—	—	—	—	—
Spongiobranchaea australis	—	—	—	1	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	—	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	1	—	—	—	—	—	—	—

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**44**				**46**	**47**	**124**		
Date	3. iv. 26				21. iv. 26	23. iv. 26	18. xii. 26		
Hour	**1855–2000**				**2200–2215**	**2200–2220**	1742–1821		
Position	32 miles N 51° E of Jason Lt, S. Georgia				51° 13′ S, 49° 50′ W	50° 55′ S, 54° 38′ W	53° 45′ 30″ S, 36° 32′ 30″ W		
Sounding (m.)	—				—	—	220		
Depth of nets (m.) ...	0–5	55(–0)	110(–0)	170(–0)	0–5	0–5	0–5	90	180(–90)
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	81	88
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	4
S. gazellae	—	—	—	—	—	—	—	—	80
Chaetognatha, *alia*	7	1	30	292	641	740	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	2
Calanus simillimus	—	—	—	—	—	—	2	2	—
C. propinquus	8, 118j	300	92	4, 316j	16j	—	136, 2j	161, 19j	36, 4j
C. acutus	—	—	—	—	—	—	—	28	145
Rhincalanus gigas	—	—	—	4	88j	—	—	1	975
Pareuchaeta antarctica	4, 38j	4, 21j	11, 35j	13, 116j	12j	4	—	22j	22j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	2000	337	60	56	6	19	3	31	12
Primno macropa	—	—	—	—	—	—	—	2	12
Vibilia antarctica	—	—	—	—	1	10	—	—	—
Cyllopus spp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	3	—	5	3	—	—	1	—	4
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	3904*	242*	50	88	—	—	—	—	—
E. frigida ♀			85	124	—	—	—	—	—
E. frigida, immature	—	2750	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	21	9	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	2*	—	—	—	—	—	—	4
E. superba ♀	1		—	—	—	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	11	—	64	26	—	—	—	—	—
E. superba, furcilia	—	—	14	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	11	112	240	—	60	—	—	—	—
T. vicina ♀	162	224	816	—	460	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	—	—	9609	—	1	—	34	80
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	64	—	—	120	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	1	1	4	4	—	2	—	—	—
L. helicina	—	—	—	—	—	—	11	2	—
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	78	—	5	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	—	1	38	—	4

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**125**			**126**			**127**		
Date	18–19. xii. 26			19. xii. 26			19. xii. 26		
Hour	**0204–0243**			1144–1203			1452–1519		
Position	53° 28′ 30″ S, 36° 20′ 30″ W			53° 58′ 30″ S, 37° 08′ W			53° 48′ 30″ S, 37° 08′ W		
Sounding (m.)	3140			100			157		
Depth of nets (m.) ...	0–5	70	140	0–5	23	47	0–5	41	82
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	11	—	—	—	—	—	—	1	—
Eukrohnia hamata	244	—	—	—	—	—	—	—	1
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	5	—	—	—	—	—	—	—	1
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—
Calanus simillimus	24	—	—	—	1	1	—	4	—
C. propinquus	456	96j	—	7	49, 2j	201, 10j	3	21	299
C. acutus	68	—	—	—	—	15	8	—	59
Rhincalanus gigas	1028	—	—	—	1	62	6	1	56
Pareuchaeta antarctica	164j	—	—	2j	—	—	—	—	3j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	124	—	—	1	—	4	—	7	9
Primno macropa	—	—	—	—	—	—	—	—	4
Vibilia antarctica	8	—	—	—	—	—	—	—	1
Cyllopus spp.	4	—	—	—	—	—	—	—	—
Amphipoda, *alia*	4	—	—	—	—	—	—	—	1
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	84*	200*	101*	1	—	—	—	1*	1
E. frigida ♀				7	—	—	—		—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	10	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	182	1440*	—	—	—	—	—	—	—
E. superba ♀	454		—	—	2	—	—	—	—
E. superba, immature	272	16	1	—	—	1	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	12	—	39	—	—	6	—	1	2
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	108	—	—	—	8	3	—	2	1
Spongiobranchaea australis	12	—	—	—	—	—	—	—	1
Salpa fusiformis	1552	40	—	—	—	—	—	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	2	2	—	8	1

* Sex not determined. j=juv.

Zooplankton Table III (*cont.*)

Station	**128**			**129**			**130**		
Date	19. xii. 26			19. xii. 26			20. xii. 26		
Hour	1809–1831			**2250–2310**			1121–1147		
Position	53° 38′ 30″ S, 37° 08′ W			53° 28′ 30″ S, 37° 08′ W			54° 06′ S, 36° 23′ W		
Sounding (m.)	167			1001			122		
Depth of nets (m.) ...	0–5	50(–0)	100	0–5	42(–0)	84(–0)	0–5	38	77
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	2	—	12	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	—	8
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	3	4	24	2	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	1	—	3	—	12	—	—	—
Calanus simillimus	13	6	1	44	—	6	—	6	5
C. propinquus	45, 1j	289	81, 52j	48	156	1092	5	40	348
C. acutus	1	1	—	—	—	—	—	—	56
Rhincalanus gigas	—	—	15	—	—	—	—	—	616
Pareuchaeta antarctica	—	—	6j	—	—	12j	—	—	11j
Pleuromamma robusta	—	—	—	—	—	21	—	—	1
Parathemisto gaudichaudi	4	4	8	135	—	60	6	13	20
Primno macropa	—	—	1	—	—	—	—	—	—
Vibilia antarctica	—	—	1	15	8	60	—	—	—
Cyllopus spp.	—	—	—	1	—	12	—	—	—
Amphipoda, *alia*	—	—	—	1	—	12	1	1	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	64*	252*	—	—	—
E. frigida ♀	—	—	—	—			—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	60	—	—	—
E. frigida, furcilia	—	—	—	—	—	24	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	116	1252	2448	—	217	10
E. superba ♀	—	—	—	104	984	1020	1	387	18
E. superba, immature	—	—	—	166	—	432	—	74	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	190	23	—	16	492	—	—	9
Thysanoessa spp. immature	—	—	4	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	14	67	25	242	—	48	28	4	1
Spongiobranchaea australis	—	—	3	25	4	12	22	—	—
Salpa fusiformis	5	2	9	239, 126j	272	5292	2	1	10
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	1	1	—	9	—	12	—	12	1

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	131			132			133		
Date	20. xii. 26			20. xii. 26			20–21. xii. 26		
Hour	1430–1508			1804–1825			0012–0119		
Position	53° 59′ 30″ S, 36° 11′ W			53° 52′ S, 35° 58′ 30″ W			53° 45′ 30″ S, 35° 46′ 30″ W		
Sounding (m.)	240			180			802		
Depth of nets (m.) ...	0–5	64	128	0–5	38	76(–0)	0–5	50	100
Medusae	—	—	—	—	—	—	—	—	2
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	1	1	—	—	—	—
Eukrohnia hamata	—	—	105	—	—	—	—	—	85
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	5	—	—	—	—	—	4
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	1	—	—	1	—
Calanus simillimus	2	14	—	17	8	—	—	4	1
C. propinquus	1	205	231	22, 5j	55	172	12j	41	628
C. acutus	1	2	53	—	—	4	—	—	16
Rhincalanus gigas	—	6	792	—	2	8	—	—	380
Pareuchaeta antarctica	—	—	1	—	—	2j	—	2j	6, 834j
Pleuromamma robusta	—	—	—	—	—	—	—	2	25
Parathemisto gaudichaudi	6	—	10	34	5	26	1128	8	21
Primno macropa	—	—	8	—	—	—	—	—	—
Vibilia antarctica	—	—	1	1	1	6	12	1	15
Cyllopus spp.	—	—	—	—	—	—	—	2	1
Amphipoda, *alia*	2	—	—	—	—	—	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	1	—	—	—	24	19	98*
E. frigida ♀	—	—	—	—	—	—	—	15	
E. frigida, immature	—	—	—	—	—	—	24	1	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	20	54
E. frigida, furcilia	—	—	—	—	—	—	—	15	22
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	128	163	—	323	482	6396	47	—
E. superba ♀	—	128	306	—	370	934	3204	6	—
E. superba, immature	—	29	52	—	77	44	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	1
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	16	20	—	24	70	—	13	87
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	28
Thysanoessa spp. cyrtopia	—	—	—	—	2	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	2
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	46	9	344	5	3	40	60	50	47
Spongiobranchaea australis	4	—	1	—	2	2	—	—	—
Salpa fusiformis	—	—	2	12	67	182	276	104	560
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	1	—	—	—	—	—	3

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**134**			**135**			**136**		
Date	21. xii. 26			21. xii. 26			21. xii. 26		
Hour	1530–1604			1902–1931			**2234–2301**		
Position	54° 22′ S, 35° 56′ W			54° 22′ S, 35° 39′ W			54° 22′ S, 35° 21′ W		
Sounding (m.)	176			243			246		
Depth of nets (m.) ...	0–5	61	123	0–5	75	150	0–5	49	99(–0)
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	65 +	1	—	1	—	—	—	1
Eukrohnia hamata	—	—	147	—	—	8	—	—	29
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	—	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—
Calanus simillimus	—	2	3	—	2	—	18	—	2
C. propinquus	89	220	102	11, 1j	187, 97j	16, 20j	194	112	325
C. acutus	—	1	520	1	2	17	3	—	5
Rhincalanus gigas	2	142	292	—	1	69	—	4	41
Pareuchaeta antarctica	3j	—	128j	1j	—	1j	—	16j	28j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	69	6	67	18	7	6	457	28	41
Primno macropa	—	1	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	1	—	5	—	2
Cyllopus spp.	1	—	—	—	—	—	—	—	1
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Antarctomysis maxima	—	—	1	—	1	1	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	14	36	45
E. frigida ♀	—	—	1	—	—	—	6	8	30
E. frigida, immature	—	—	18	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	2
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	69	14	36	11	9	1	179	976	372
E. superba ♀	91	29	104	18	12	11	380	1152	493
E. superba, immature	—	—	—	6	—	—	196	24	17
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	1	13	—	28	4	2	32	19
Thysanoessa spp. immature	—	—	—	—	—	—	21	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	1	3	3	—	8	—	—	—	24
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	2	—	—	—	—	45, 118j	192	81, 22j
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	125	4	88	767	2	3	69	—	1

j = juv.

Zooplankton Table III (*cont.*)

Station	**137**			**138**			**139**		
Date	22. xii. 26			22. xii. 26			22–23. xii. 26		
Hour	0528–0600			1102–1140			**0008–0041**		
Position	54° 19′ 30″ S, 35° 03′ 30″ W			54° 17′ S, 34° 47′ W			53° 30′ 15″ S, 35° 50′ 45″ W		
Sounding (m.)	740			2530			3230		
Depth of nets (m.) ...	0–5	66	132	0–5	77	155	0–5	90	180
Medusae	—	—	—	—	1	—	—	3	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	1 +	—	—
Eukrohnia hamata	—	64	58	—	54	24	—	65	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	1	—	—	—
S. gazellae	—	3	—	—	—	—	2	2	1
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—
Calanus simillimus	3	—	—	—	—	—	11	—	—
C. propinquus	5	33	173, 76j	—	33	134, 497j	75	66, 79j	42, 5j
C. acutus	1	432	16	—	2	25	—	6	9
Rhincalanus gigas	—	533	606	—	23	590	—	18	25
Pareuchaeta antarctica	—	4j	16j	—	7j	83j	—	335j	17j
Pleuromamma robusta	—	—	—	—	—	—	—	75	8
Parathemisto gaudichaudi	26	107, 606j	15	5	37	48	121	6	1
Primno macropa	1	2	1	—	2	2	—	—	—
Vibilia antarctica	—	29	—	—	7	—	4	1	—
Cyllopus spp.	—	1	—	—	—	—	—	—	—
Amphipoda, *alia*	320j	1	—	—	—	—	1	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	4	11	2
E. frigida ♀	—	—	—	—	—	—	3	14	7
E. frigida, immature	—	—	6	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	5	2	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	3	139	1	—	189	24	208	23	8
E. superba ♀	1	138	2	—	351	17	99	5	2
E. superba, immature	—	—	—	—	14	—	20	7	—
E. superba, cyrtopia	—	—	—	3	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	3	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	2	—
T. macrura ♀	—	—	—	—	—	—	—	8	—
Thysanoessa spp.	—	9	24	—	12	5	4	—	5
Thysanoessa spp. immature	—	—	—	—	—	—	—	2	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	12	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	690	—	1	496	—	20	11	6
Spongiobranchaea australis	—	2	—	—	4	—	5	—	—
Salpa fusiformis	2	1340, 53j	40, 3j	—	104	77, 27j	333, 149j	73	22
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	10	—	4	2	—	—	—	2	—

j = juv.

Zooplankton Table III (*cont.*)

Station	**151**				**160**		
Date	16. i. 27				7. ii. 27		
Hour	1236–1314				1515–1543		
Position	53° 25′ S, 35° 15′ W				Near Shag Rocks, 53° 43′ 40″ S, 40° 57′ W		
Sounding (m.)	3200				177		
Depth of nets (m.) ...	0–5	56	112	500–625	0–5	40	80(–0)
Medusae	—	—	—	1	—	—	—
Beroë	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	181	—	—	—
Sagitta maxima	—	—	—	8	—	—	—
S. planktonis	—	—	—	2	—	—	—
S. gazellae	—	—	—	4	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—
Calanus simillimus	—	—	—	—	—	12	—
C. propinquus	—	—	—	28j	—		—
C. acutus	—	—	—	88	—		—
Rhincalanus gigas	—	—	—	138	—	—	—
Pareuchaeta antarctica	—	—	—	1	—	—	—
Pleuromamma robusta	—	—	—	82	—	—	—
Parathemisto gaudichaudi	—	14	23	2	—	23	42
Primno macropa	—	1	3	—	—	—	—
Vibilia antarctica	—	—	6	—	—	—	—
Cyllopus spp.	—	3	4	1	—	—	—
Amphipoda, *alia*	—	—	—	4	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—
E. superba ♂	—	38	16	—	—	3	1*
E. superba ♀	—	51	36	—	—	—	
E. superba, immature	—	175	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	71*
T. vicina ♀	—	—	—	—	—	—	
T. macrura ♂	—	—	—	2	—	—	—
T. macrura ♀	—	—	—	—	—	—	—
Thysanoessa spp.	—	37	57	—	—	—	—
Thysanoessa spp. immature	—	—	—	—	—	—	500
Thysanoessa spp. cyrtopia	—	—	—	1	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—
L. helicina	—	—	—	1	—	—	—
Spongiobranchaea australis	—	—	—	—	—	1	1
Salpa fusiformis	—	2	232, 15j	3+	—	—	—
Oikopleura	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	—	—	—

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**161**			**WS 18**			**WS 19**		
Date	14. ii. 27			26. xi. 26			27. xi. 26		
Hour	1158–1219			1905–1950			1326–1403		
Position	57° 21′ 20″ S, 46° 43′ 30″ W			54° 07′ S, 36° 23′ W			54° 00′ 30″ S, 36° 20′ 30″ W		
Sounding (m.)	3459			113			128		
Depth of nets (m.) ...	0–5	38	79(–0)	0–5	49	118	0–5	77	164
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	1	—	—	—	—
Eukrohnia hamata	—	—	—	1	—	75	1	59	71
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	7	—	2	1
Chaetognatha, *alia*	—	—	—	—	—	—	—	9	1
Tomopteris spp.	—	—	—	—	—	—	—	1	—
Calanus simillimus	21	—	250	—	—	—	3	1	—
C. propinquus		—		10	4	120, 5j	164	154, 30j	104, 8j
C. acutus		—		6	—	1	22	14	32
Rhincalanus gigas	1	—	—	—	—	318	—	721	646
Pareuchaeta antarctica	—	—	—	—	—	—	—	1, 2j	20j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	10	—	17	—	—	—	—	—	2
Primno macropa	—	—	—	—	—	—	—	—	1
Vibilia antarctica	—	—	12	1	—	—	—	—	1
Cyllopus spp.	—	—	19	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Antarctomysis maxima	—	—	—	—	—	5	—	2	1
Euphausia frigida ♂	—	—	—	—	—	—	—	1	3
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	1*	—	—	—	—	—	—	—	—
E. superba ♀									
E. superba, immature	—	—	—	1	—	1	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	1*	—	—	—	—	—	—
T. vicina ♀	—	—							
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	—	—	—	—	—	—	4	14
Thysanoessa spp. immature	—	—	—	2	—	11	—	1	1
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	2	—	714	2	—	40	—	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	1	—	2	1	1	—

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 20**			**WS 21**			**WS 22**		
Date	28. xi. 26			28. xi. 26			30. xi. 26		
Hour	1035–1132			1634–1716			1903–1946		
Position	53° 52′ 30″ S, 36° 00′ W			53° 45′ 30″ S, 35° 48′ W			53° 38′ S, 35° 35′ W		
Sounding (m.)	535			899			2260		
Depth of nets (m.) ...	0–5	86	190	0–5	95	192	0–5	82	185
Medusae	—	—	3	—	—	1	1	—	1
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	1	1	1	—	1	—	1	3+
Eukrohnia hamata	1	80	83	—	36	208	46	74	—
Sagitta maxima	—	—	1	—	—	—	—	—	—
S. planktonis	—	—	—	1	—	6	—	—	—
S. gazellae	—	1	—	—	2	—	1	3	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	2	—	—	—	—
Calanus simillimus	3	5	—	—	—	—	(Cope-	5	22
C. propinquus	160	117, 11j	204	274	210, 14j	65, 13j	poda	97	84, 6j
C. acutus	133	373	531	1	25	93	352)*	141	53
Rhincalanus gigas	—	275	246	2	411	342		48	186
Pareuchaeta antarctica	—	3j	6j	—	3j	9j		5j	14j
Pleuromamma robusta	—	—	—	—	—	—		—	—
Parathemisto gaudichaudi	3	—	2	5	2	3	5	3	26
Primno macropa	—	—	—	—	—	—	—	—	1
Vibilia antarctica	—	3	3	—	3	10	3	53	6
Cyllopus spp.	—	—	1	—	—	—	—	—	2
Amphipoda, *alia*	—	—	1	—	—	—	—	—	1
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	4	6	—	—	1	—	—	1
E. frigida ♀	—	7	5	—	—	—	—	—	1
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	2	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	2	—	—	—	—	—	—
E. superba ♀	—	—	6	—	—	1	—	—	4
E. superba, immature	—	—	—	—	—	—	13	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	1	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	19	34	—	42	18	—	5	14
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	1	—	—	21	3	—	—	28	5
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	13	108, 20j	367	—	180	98	55	19	103
Oikopleura	—	4	—	1	—	—	1	4	—
Fish juv.	3	—	2	—	—	—	1	—	—

* Record of further analysis lost. j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 24**			**WS 26**			**WS 27**		
Date	10. xii. 26			18. xii. 26			19. xii. 26		
Hour	1651–1722			**2240–2311**			0745–0815		
Position	54° 12′ 07″ S, 36° 28′ 07″ W			53° 33′ 15″ S, 37° 45′ 15″ W			53° 55′ S, 38° 01′ W		
Sounding (m.)	172–212			1180			80		
Depth of nets (m.) ...	0–5	68	137	0–5	96	192	0–5	53	107
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	1	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	15	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	3	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—
Calanus simillimus	—	4	—	—	12	—	1	—	—
C. propinquus	22	6	—	—	519, 42j	36	76	—	—
C. acutus	—	7	—	—	6	3	—	—	—
Rhincalanus gigas	—	7	—	—	78	453	—	—	—
Pareuchaeta antarctica	—	—	—	—	5j	27j	—	—	—
Pleuromamma robusta	—	—	—	—	58	10	—	—	—
Parathemisto gaudichaudi	2	—	—	—	3	—	—	—	—
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	1	—	—	—	—	—	—	—
Cyllopus spp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	3	96	—	—	—
E. frigida ♀	—	—	—	—	8	98	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	1	70	—	42,500*	—	—	2	—	—
E. superba ♀	9	68	—		—	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	—	—	—	130	79	—	—	—
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	5	—	—	—
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	2	4	—	—	20	30	—	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	2	—	—	—	—	1	—	—	—

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 28**		**WS 29**			**WS 30**		
Date	19. xii. 26		19. xii. 26			19–20. xii. 26		
Hour	1119–1149		1602–1632			**2258–2328**		
Position	53° 48′ 15″ S, 38° 13′ W		53° 41′ 15″ S, 38° 24′ 45″ W			53° 34′ 15″ S, 38° 36′ 15″ W		
Sounding (m.)	150–346		614			2582		
Depth of nets (m.) ...	0–5	80	0–5	59	118	0–5	67	134(–67)
Medusae	—	1	—	—	—	—	8	—
Beroë	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	3	4	—
Eukrohnia hamata	—	7	—	—	—	—	—	840
Sagitta maxima	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—
S. gazellae	—	3	1	—	12	3	—	24
Chaetognatha, *alia*	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	1	—	—
Calanus simillimus	—	1	—	—	—	2	—	—
C. propinquus	16	2	2	—	96, 6j	151	40	192
C. acutus	—	6	—	—	—	22	324	1368
Rhincalanus gigas	—	107	—	—	251	1j	44	4500
Pareuchaeta antarctica	—	—	—	—	—	—	8j	52j
Pleuromamma robusta	—	—	—	—	—	—	4	76
Parathemisto gaudichaudi	—	7	1	—	16	2	—	—
Primno macropa	—	—	—	—	7	—	—	—
Vibilia antarctica	—	2	—	—	10	8	4	16
Cyllopus spp.	—	—	—	—	2	1	—	—
Amphipoda, *alia*	—	—	—	—	1	—	—	—
Antarctomysis maxima	—	5	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	27*	—	20
E. frigida ♀	—	—	—	—	—		20	40
E. frigida, immature	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	4	—
E. frigida, furcilia	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	1	2	148	—	—
E. superba ♀	—	2	—	4	7	64	—	—
E. superba, immature	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	1	—	—	63	—	68	700
Thysanoessa spp. immature	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	1	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	4
Spongiobranchaea australis	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	2	2	213	372, 14j	892	236
Oikopleura	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	—	—	—	12

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 31**		**WS 33**			**WS 34**	
Date	20. xii. 26		21. xii. 26			21. xii. 26	
Hour	1653–1723		1702–1732			**2010–2040**	
Position	54° 52′ S, 35° 36′ W		54° 59′ S, 35° 24′ W			55° 06′ S, 35° 11′ W	
Sounding (m.)	76		135			121	
Depth of nets (m.) ...	0–5	53	0–5	65	130	0–5	100
Medusae	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—
Ctenophora, *alia*	—	1	—	—	—	3	1 +
Eukrohnia hamata	—	3	—	—	—	—	1
Sagitta maxima	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—
S. gazellae	—	1	—	—	—	—	—
Chaetognatha, *alia*	—	1	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	1	—
Calanus simillimus	—	1	1	3	—	—	—
C. propinquus	19	14, 12j	31, 24j	39, 70j	—	88, 52j	5, 33j
C. acutus	4	145	3	8	—	10	78
Rhincalanus gigas	—	35	—	1	—	2	72
Pareuchaeta antarctica	—	2j	—	—	—	—	2j
Pleuromamma robusta	—	—	—	—	—	—	—
Parathemisto gaudichaudi	4	34	3	20	—	106	2
Primno macropa	—	—	—	—	—	—	—
Vibilia antarctica	—	1	—	—	—	—	—
Cyllopus spp.	—	—	—	—	—	—	1
Amphipoda, *alia*	—	1	—	—	—	1	4
Antarctomysis, maxima	—	1	—	1	—	—	16
Euphausia frigida ♂	—	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	1	—	42
E. frigida, furcilia	—	—	—	—	—	3	—
E. frigida, calyptopis	—	—	—	—	—	—	—
E. superba ♂	—	1	—	—	—	—	—
E. superba ♀	—	3	—	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—
E. superba, cyrtopia	—	1	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—
Thysanoessa spp.	—	23	—	9	—	—	3
Thysanoessa spp. immature	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	8
Thysanoessa spp. furcilia	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—
L. helicina	1	3	4	62	—	3	13
Spongiobranchaea australis	—	1	—	—	—	—	—
Salpa fusiformis	15	2	1	—	—	—	4
Oikopleura	—	—	—	—	—	—	1
Fish juv.	—	14	2	1	—	12	1

j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 35**			**WS 36**			**WS 37**		
Date	21–22. xii. 26			22. xii. 26			22. xii. 26		
Hour	**0155–0225**			0732–0802			1622–1652		
Position	55° 13′ 15″ S, 34° 59′ W			55° 20′ 15″ S, 34° 46′ 30″ W			54° 45′ S, 35° 11′ W		
Sounding (m.)	161			1242			318		
Depth of nets (m.) ...	0–5	51	102(–51)	5–0	77	155	0–5	80	159
Medusae	—	1	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	6	—	1	—	—	—	—	4	—
Eukrohnia hamata	—	—	88	—	7	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	4	—	1	—	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	4	—	1	—	—	—	—
Calanus simillimus	7	3	8	—	—	—	—	12	—
C. propinquus	135	68, 48j	296	1, 1j	446	—	—	188	—
C. acutus	12	14	20	—	8	—	—	—	—
Rhincalanus gigas	—	—	252	2	184	—	—	4	—
Pareuchaeta antarctica	—	1j	52j	—	4j	—	—	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	136	14	20	5	59	4	—	24	—
Primno macropa	—	—	—	—	10	—	—	—	—
Vibilia antarctica	—	—	—	—	2	4	—	20	—
Cyllopus spp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Antarctomysis maxima	—	1	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	22	24	—	—	—	—	—	—
E. frigida, furcilia	—	22	16	—	2	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	—	13	—	—	—	—
E. superba ♀	—	—	—	—	12	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	22	—	8	—	11	—	—	8	—
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	9	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	1	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	2	—	—	—	—	—	—	—
L. helicina	15	79	88	2	249	28	2	44	—
Spongiobranchaea australis	—	—	—	—	1	—	—	4	—
Salpa fusiformis	5	14	164	—	114	276	—	420	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	6	—	—	1	1	—	—	—	—

j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 38**			**WS 39**			**WS 40**		
Date	22–23. xii. 26			23. xii. 26			7. i. 27		
Hour	**0247–0317**			0723–0753			0812–0842		
Position	54° 01′ S, 35° 14′ W			54° 08′ S, 35° 43′ W			55° 09′ S, 35° 58′ W		
Sounding (m.)	2103			237			183		
Depth of nets (m.) ...	0–5	53	106(–53)	0–5	87?	173?	0–5	72	144
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	1	—	—	—	1	—
Eukrohnia hamata	—	—	44	—	—	4	—	6	33
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	1	—	1	3
Chaetognatha, *alia*	—	—	—	—	—	2	—	—	—
Tomopteris spp.	—	1	—	—	—	1	—	—	—
Calanus simillimus	—	1	—	6	—	—	—	—	—
C. propinquus	—	2, 21j	192, 468j	1, 1j	22, 46j	7, 37j	—	2086	1080
C. acutus	—	—	—	—	—	2	—	1229	84
Rhincalanus gigas	—	1	564	—	7	134	—	2360	564
Pareuchaeta antarctica	—	3j	84j	—	—	4j	—	—	12j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	36	5	64	4	3	12	—	25	3
Primno macropa	—	1	8	—	—	—	—	—	—
Vibilia antarctica	91	1	—	—	—	—	—	2	—
Cyllopus spp.	—	—	—	—	—	—	—	—	2
Amphipoda, *alia*	—	1	—	—	—	—	—	1	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	16	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	1024	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	4	—	72	—	5	232	—	—	—
E. superba ♀	—	4	68	—	21	139	—	—	—
E. superba, immature	—	—	24	—	—	365	—	—	179
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	6	—
T. vicina ♀	—	—	—	—	—	—	—	11	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	—	56	—	—	13	—	—	15
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	1519	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	16	6
L. helicina	—	94	96	—	—	109	—	128	13
Spongiobranchaea australis	—	1	—	—	—	—	—	4	3
Salpa fusiformis	10,730	105	—	2	20	36	—	154, 9j	39
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	1	—	—	—	—	—	3	—

j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 41**			**WS 42**			**WS 43**		
Date	7. i. 27			7. i. 27			7–8. i. 27		
Hour	1508–1538			**2010–2040**			**2346–0016**		
Position	54° 32′ 45″ S, 36° 43′ 45″ W			54° 41′ 45″ S, 36° 47′ W			54° 54′ S, 36° 50′ W		
Sounding (m.)	140			175			200		
Depth of nets (m.) ...	0–5	73	146	0–5	99	198	0–5	70	141
Medusae	—	—	1	1	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	1	1	1	89	13+	1+	—	—	—
Eukrohnia hamata	—	—	3	—	—	—	—	39	80
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	2	—	—	—	—	—	1
Chaetognatha, *alia*	—	—	1	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	3	—
Calanus simillimus	—	—	—	—	—	1	—	—	—
C. propinquus	2, 4j	10, 126j	30	83	—	11j	560j	956	128
C. acutus	5	226	57	23	—	34	112	45	8
Rhincalanus gigas	1	102	54	—	—	34	16	144	130
Pareuchaeta antarctica	—	1j	4, 146j	1j	—	1, 33j	—	29j	1, 31j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	—	3	3	54	—	—	16	3	3
Primno macropa	—	—	—	—	—	—	—	—	1
Vibilia antarctica	—	—	—	1	—	—	—	—	—
Cyllopus spp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	1	—	—	—	—	—	4
Antarctomysis maxima	—	—	101	—	2	7, 5j	32	877	172
Euphausia frigida ♂	—	—	—	—	—	—	—	8	—
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	8	7	—	—	—	216	80	6
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	—	2	1	—	8	49
E. superba ♀	—	—	—	—	—	3	16	24	4
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	4	—	3	—	—	—	64	14
T. vicina ♀	—	—	—	1	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	40	5
T. macrura ♀	—	—	—	—	—	—	—	104	—
Thysanoessa spp.	—	—	17	—	1	—	—	—	28
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	24	2	10	—	6	216	8	—
Thysanoessa spp. furcilia	—	—	3	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	12	2	2	82	—	—	4768	11	21
Spongiobranchaea australis	—	—	—	—	—	—	16	—	—
Salpa fusiformis	—	—	—	5	—	—	7	2	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	6	91	1	—	4	16	1	5

j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 44**			**WS 45**			**WS 46**		
Date	8. i. 27			8. i. 27			8. i. 27		
Hour	0839–0909			1801–1831			2300–2330		
Position	55° 06′ S, 36° 57′ W			54° 38′ 30″ S, 37° 30′ 55″ W			54° 20′ 15″ S, 37° 32′ 30″ W		
Sounding (m.)	1470			180			194		
Depth of nets (m.) ...	0–5	64	128	0–5	51	102	0–5	73	146
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	1	—	—	—	—	1
Eukrohnia hamata	—	—	5	—	—	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	1	—	—	—	—	—	—	2	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	3	—	—	2+	—
Calanus simillimus	—	—	—	2	—	—	18	—	—
C. propinquus	1, 18j	184	4j	12, 14j	55	2	1664	738	20j
C. acutus	—	12	8	43	345	796	110	592	32
Rhincalanus gigas	4	354	57	—	211	6	—	586	30
Pareuchaeta antarctica	3j	7j	—	—	—	—	4, 292j	2, 28j	4j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	—	32	1	—	60	29	4	20	—
Primno macropa	—	5	—	—	—	—	—	—	—
Vibilia antarctica	—	3	—	—	4	—	—	—	—
Cyllopus spp.	—	1	—	—	—	—	—	—	—
Amphipoda, *alia*	—	1	—	—	1	2	—	2	—
Antarctomysis maxima	—	6, 108j	—	1	129	319	—	390	12
Euphausia frigida ♂	—	—	—	—	—	—	—	—	—
E. frigida ♀	1	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	20	} 266	1
E. frigida, furcilia	—	—	—	—	—	—	—		—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	—	—	—	2	—	—
E. superba ♀	—	—	—	—	—	—	4	—	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	258	—
T. vicina ♀	—	—	—	—	—	—	—	276	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	22	—
Thysanoessa spp.	—	4	—	—	—	—	6	—	4
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	51	—	1	72	6	18	22	—
Thysanoessa spp. furcilia	—	51	—	—	—	1	2	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	25	101	3	22	6	7	16	6	—
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	1	126, 4j	—	—	—	—	36	18	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	2	1	—	30	—

j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 47**			**WS 48**			**WS 49**		
Date	9. i. 27			9. i. 27			9. i. 27		
Hour	**0248–0318**			0612–0642			0931–1001		
Position	54° 22′ S, 37° 50′ W			54° 24′ S, 38° 09′ W			54° 28′ S, 38° 22′ 15″ W		
Sounding (m.)	160			224			223		
Depth of nets (m.) ...	0–5	63	126	0–5	96	192	0–5	69	137
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	9	—	—	—	—	—
Ctenophora, *alia*	200	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	9	—	—	19
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	8	—	—	2	3	—	—	3
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	1	—	—	—	—	—
Calanus simillimus	4	—	—	9	—	—	—	—	1
C. propinquus	360	720	40	28	53j	24	2	7	12, 312j
C. acutus	—	36	—	56	57	1	1	207	2
Rhincalanus gigas	—	208	8	—	63	1	—	1055	9, 31j
Pareuchaeta antarctica	2, 64j	20	—	—	1, 4j	11, 66j	—	1j	2j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	58	4	60	7j	3	3	6j	3	—
Primno macropa	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus spp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Antarctomysis maxima	34	1624	1128	1	36	267	2	69	221
Euphausia frigida ♂	—	—	—	—	—	1	—	—	1
E. frigida ♀	—	—	—	—	—	1	—	—	1
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	4	16	8	—	—	—	—	12	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	—	—	—	—	—	—
E. superba ♀	—	—	—	—	—	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	5	—
T. macrura ♀	—	—	—	—	—	—	—	5	—
Thysanoessa spp.	2	152	12	—	10	21	—	—	15
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	79
Thysanoessa spp. cyrtopia	—	—	4	—	2	—	—	13	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	284	12	—	26	5	1	1	1	1
Spongiobranchaea australis	—	—	—	1	1	—	—	—	—
Salpa fusiformis	2	—	—	—	—	—	—	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	6	24	12	—	33	11	—	376	5

j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 50**			**WS 51**			**WS 52**	
Date	9. i. 27			9. i. 27			10. i. 27	
Hour	1334–1404			1654–1724			0830–0900	
Position	54° 30′ 30″ S, 38° 40′ 30″ W			54° 34′ S, 38° 57′ W			54° 03′ 30″ S, 38° 35′ W	
Sounding (m.)	230			210			184	
Depth of nets (m.) ...	0–5	71	142	0–5	64	128	0–5	100
Medusae	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	1	1	—
Eukrohnia hamata	—	—	125	—	4	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—
S. gazellae	—	—	8	—	—	9	—	3
Chaetognatha, *alia*	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—
Calanus simillimus	1	—	3	—	—	—	—	—
C. propinquus	2	2	1, 29j	1j	3, 28j	9, 66j	—	1, 1j
C. acutus	—	60	1	—	12	6	—	1
Rhincalanus gigas	—	501	38	1	30	33, 48j	—	54
Pareuchaeta antarctica	—	—	—	—	—	6j	—	—
Pleuromamma robusta	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	—	1	—	1	1	—	5	1
Primno macropa	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	1
Cyllopus spp.	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	3	—	—
Antarctomysis maxima	—	11	—	—	102	2430, 36j	—	1
Euphausia frigida ♂	—	—	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	26	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	—	—	—	—	—
E. superba ♀	—	—	—	—	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	2	16	—	—	15	—	8
Thysanoessa spp. immature	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	2	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—
L. helicina	3	—	2	—	—	3	3	1
Spongiobranchaea australis	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	3	—	—
Oikopleura	—	—	—	—	—	—	—	—
Fish juv.	1	6	4	—	1	12	—	3

j = juv.

Zooplankton Table III (*cont.*)

Station	WS 54			WS 55			WS 57		
Date	12. i. 27			12. i. 27			17. i. 27		
Hour	0656–0726			0942–1012			1156–1226		
Position	53° 29′ S, 37° 13′ 45″ W			53° 15′ 30″ S, 37° 13′ 45″ W			53° 37′ S, 36° 51′ W		
Sounding (m.)	2281			—			—		
Depth of nets (m.) ...	0–5	70	140	0–5	82	164	0–5	66	132
Medusae	—	—	—	—	—	—	—	—	2
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	1	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	3	—	—	—	—	—	11
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	1	1	—	—	—	—	—	7
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	1	—	—	—
Calanus simillimus	—	—	—	—	—	—	—	—	1
C. propinquus	—	—	3, 50j	—	—	3j	—	9j	13, 41j
C. acutus	—	—	—	—	—	—	—	—	7j
Rhincalanus gigas	—	4	—	—	—	—	—	3, 2j	10, 31j
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	1j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	—	—	34	—	—	8	464	8	6
Primno macropa	—	—	—	—	—	—	1	1	—
Vibilia antarctica	1	—	8	—	—	—	—	3	4
Cyllopus spp.	—	—	—	—	—	—	—	1	—
Amphipoda, *alia*	—	1	—	—	—	—	—	—	2
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	—	—	24
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	15
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	3	5	3	—	—	3	2	55	—
E. superba ♀	4	3	—	—	—	3	7	82	—
E. superba, immature	—	—	2	—	—	—	—	—	—
E. superba, cyrtopia	1	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	6	6	—	—	76	29	—	8
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	13	6	—	—	3	—	—	1
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	6	8	186, 118j	—	—	8, 1j	—	33	90, 8j
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	—	—	—	—	3

j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 58**			**WS 59**			**WS 60**		
Date	17. i. 27			17. i. 27			17. i. 27		
Hour	1708–1738			1905–1935			**2125–2155**		
Position	53° 06′ 15″ S, 37° 06′ 30″ W			52° 57′ S, 37° 06′ 30″ W			52° 47′ S, 37° 06′ 30″ W		
Sounding (m.)	—			—			—		
Depth of nets (m.) ...	0–5	56	112	0–5	56	113	0–5	73	146
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	—	—	—	—	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	8	—	—	2	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—
Calanus simillimus	—	—	—	—	—	—	7	—	—
C. propinquus	17j	—	2, 40j	—	—	19, 169j	81, 1151j	2, 25j	8, 156j
C. acutus	—	—	—	—	—	—	—	—	—
Rhincalanus gigas	—	—	—	—	—	1j	—	—	—
Pareuchaeta antarctica	—	—	—	—	—	—	—	3j	1, 83j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	8	74	—	—	21	8	22	1	8
Primno macropa	1	—	2	2	—	—	—	1	—
Vibilia antarctica	—	44	4	—	28	3	—	1	5
Cyllopus spp.	1	24	4	1	6	—	2	—	6
Amphipoda, *alia*	—	—	2	—	—	—	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	—	5	24
E. frigida ♀	—	—	—	—	—	—	—	6	24
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	111	144	—	43	—	—	2	—
E. superba ♀	1	237	192	—	81	3	—	1	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	2	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	1	—	—
Thysanoessa spp.	1	—	38	1	—	6	—	9	88
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	8	—	3	105	—	—
Thysanoessa spp. furcilia	—	—	—	2	—	—			
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	48	4	—	302	138	7	85	—
Spongiobranchaea australis	—	8	—	—	2	—	—	—	—
Salpa fusiformis	1	1544, 6j	108	35, 3j	225, 28j	46	15	11	482, 47j
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	2	—	—	4	—	—	—

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 61**			**WS 63**			**WS 66**	
Date	18. i. 27			20–21. i. 27			18. ii. 27	
Hour	**0100–0130**			**2301–2331**			1005–1035	
Position	52° 37′ 30″ S, 37° 06′ 30″ W			54° 36′ S, 39° 14′ W			53° 31′ 15″ S, 42° 03′ 30″ W	
Sounding (m.)	1892–2201			1752			150	
Depth of nets (m.) ...	0–5	61	132	0–5	79	157	0–5	88
Medusae	—	—	2	—	28	—	—	—
Beroë	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	15	4	—	—	—	1
Sagitta maxima	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—
S. gazellae	3	—	4	4	—	—	—	—
Chaetognatha, *alia*	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	4	—	—	—
Calanus simillimus	1	—	—	8	—	—	—	—
C. propinquus	22, 452j	1, 4j	17, 141j	488j	8, 440j	4, 184j	—	5
C. acutus	—	—	—	—	12	76	—	—
Rhincalanus gigas	—	—	—	—	—	136j	—	3
Pareuchaeta antarctica	—	—	130j	—	176j	672j	—	—
Pleuromamma robusta	—	—	13	—	12	108	—	—
Parathemisto gaudichaudi	8	3	1	192	—	4	—	3
Primno macropa	—	—	—	—	—	—	—	1
Vibilia antarctica	—	4	1	16	4	—	—	—
Cyllopus spp.	7	4	2	4	—	—	—	—
Amphipoda, *alia*	1	1	—	—	—	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	5	—	44	8	—	—
E. frigida ♀	—	—	11	—	24	20	—	—
E. frigida, immature	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	6	12	64	20	—	—
E. frigida, furcilia	—	—	—	—	4	4	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—
E. superba ♂	17	14	—	128	—	—	—	—
E. superba ♀	39	36	1	240	—	4	—	—
E. superba, immature	—	1	—	—	—	—	—	—
E. superba, cyrtopia	—	—	1	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	4	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	11	104	—	32	44	—	—
Thysanoessa spp. immature	—	—	—	—	—	—	—	—
Thysanoessa spp. cyrtopia	9	—	2	72	52	72	—	—
Thysanoessa spp. furcilia	1	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	14
L. helicina	—	1	11	—	—	—	—	—
Spongiobranchaea australis	—	—	—	4	—	—	—	—
Salpa fusiformis	95, 1+j	460	52, 4j	440, 4j	356	352, 16j	—	—
Oikopleura	—	—	—	—	—	—	—	—
Fish juv.	—	—	1	—	—	—	—	1

j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 67**			**WS 68**			**WS 69**		
Date	20. ii. 27			21. ii. 27			22. ii. 27		
Hour	1107–1230			0630–0701			0244–0322		
Position	53° 19′ S, 45° 16′ W			52° 53′ S, 48° 48′ W			52° 19′ S, 52° 11′ W		
Sounding (m.)	1839			3197			2743		
Depth of nets (m.) ...	0–5	66	133	0–5	80	161	0–5	73	146
Medusae	—	—	—	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	21	4	—	103	20	—	—	—
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	—	—	—	18	19	—	6
Chaetognatha, *alia*	—	—	—	—	—	—	—	9	—
Tomopteris spp.	—	3	—	—	—	—	—	—	1
Calanus simillimus	—	—	—	—	—	—	—	1	—
C. propinquus	1	18	8	—	6	—	—	—	2, 5j
C. acutus	—	4	1	—	—	—	—	—	—
Rhincalanus gigas	—	46	22	—	4	—	—	1j	2j
Pareuchaeta antarctica	—	—	—	—	—	—	—	1j	6, 163j
Pleuromamma robusta	—	—	—	—	—	—	—	—	59
Parathemisto gaudichaudi	3j	5	2	7j	—	7	73	2j	10, 1j
Primno macropa	1	1	—	1	—	4	—	—	11
Vibilia antarctica	1	—	1	—	—	—	227	—	12
Cyllopus spp.	—	—	—	—	—	—	57	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	—	—	—
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	—	—	—	—	—	—
E. superba ♀	—	—	—	—	—	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	2*	—	—	—	—
T. vicina ♀	—	—	—	—		—	—	—	—
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	—	—	—	—	—	—	—	—
Thysanoessa spp. immature	—	—	—	—	—	2	—	—	450
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	18
L. helicina	—	—	—	—	5	—	—	—	—
Spongiobranchaea australis	—	3	—	—	—	1	1	—	—
Salpa fusiformis	1	—	3	1	—	—	383	8	94+
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	1	—	—	—	1

* Sex not determined. j = juv.

Zooplankton Table III (*cont.*)

Station	**WS 70**			**WS 110**			**WS 111**		
Date	22–23. ii. 27			26. v. 27			26–27. v. 27		
Hour	**0049–0119**			**1634–1704**			**1946–2016**		
Position	51° 58′ S, 55° 42′ W			53° 46′ S, 35° 47′ W			53° 39′ S, 35° 34′ W		
Sounding (m.)	—			988			1500		
Depth of nets (m.) ...	0–5	73	146	0–5	51	102(–0)	0–5	(100)–50	(200)–100
Medusae	—	—	1	—	—	—	—	—	—
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—
Eukrohnia hamata	—	—	4	—	—	62	—	5	25
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	1	—	4	—	—	8	—	—	3
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—
Calanus simillimus	—	4	—	—	—	2	—	—	—
C. propinquus	—	—	3j	—	16, 16j	20, 28j	—	1, 1j	4, 12j
C. acutus	—	—	—	—	—	1	—	—	—
Rhincalanus gigas	—	—	—	—	—	5j	—	—	1j
Pareuchaeta antarctica	—	3j	7, 24j	—	—	—	—	17j	14j
Pleuromamma robusta	—	—	129	—	—	—	—	—	1
Parathemisto gaudichaudi	89	1	33	40	—	4	—	—	—
Primno macropa	—	—	2	6	—	—	—	—	—
Vibilia antarctica	74	—	19	—	—	—	—	—	—
Cyllopus spp.	46	—	4	—	—	—	—	—	—
Amphipoda, *alia*	—	1	—	—	—	—	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	1*	—	—	105	—	3	12
E. frigida ♀	—	—		—	—	169	—	17	3
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	—	—	—	—	—	—	—	4	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	—	—	195	444	3	—	8	—
E. superba ♀	—	—	—	225	540	7	—	10	—
E. superba, immature	—	—	—	—	—	—	—	—	—
E. superba, cyrtopia	—	—	—	119	8	136	—	—	92
E. superba, furcilia	—	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	—	—	—	—	—	—	—	—	—
T. vicina ♀	—	—	—	—	—	—	—	—	—
T. macrura ♂	—	—	9*	—	—	—	—	—	—
T. macrura ♀	—	—		—	—	—	—	—	—
Thysanoessa spp.	—	—	—	116	64	201	—	14	18
Thysanoessa spp. immature	12	—	131	—	8	—	—	—	—
Thysanoessa spp. cyrtopia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—
Spongiobranchaea australis	1	—	2	—	—	—	—	—	—
Salpa fusiformis	201j	13	25	—	—	—	—	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	—	—	—	—	—	—	—	—	—

* Sex not determined. j=juv.

Zooplankton Table III (*cont.*)

Station	WS 112			WS 113			WS 114		
Date	27. v. 27			28. v. 27			28. v. 27		
Hour	1233–1303			1015–1045			1321–1351		
Position	53° 54′ 30″ S, 36° 06′ W			54° 07′ S, 36° 24′ W			54° 00′ S, 36° 12′ W		
Sounding (m.)	155			155			163		
Depth of nets (m.) ...	0–5	73	146	0–5	55	110	0–5	58	116
Medusae	—	—	—	—	—	1	—	—	1
Beroë	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	1	—	—	—	—	—	—	1
Eukrohnia hamata	—	—	52	—	—	96	—	—	191
Sagitta maxima	—	—	—	—	—	—	—	—	—
S. planktonis	—	—	—	—	—	—	—	—	—
S. gazellae	—	—	2	—	—	2	—	—	17
Chaetognatha, *alia*	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—
Calanus simillimus	1	—	—	—	—	—	—	—	—
C. propinquus	16, 27j	2, 1j	1, 14j	—	—	18, 24j	152j	2j	20, 54j
C. acutus	—	—	6	—	—	7	—	—	—
Rhincalanus gigas	—	1j	33j	—	—	36, 109j	4j	—	20, 50j
Pareuchaeta antarctica	—	—	8j	—	—	—	40j	—	2j
Pleuromamma robusta	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	—	2	1	—	8	—	4	7	5
Primno macropa	1	—	—	—	—	—	—	1	—
Vibilia antarctica	—	—	—	—	—	—	—	—	—
Cyllopus spp.	—	—	—	—	—	—	—	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—
Antarctomysis maxima	—	—	—	—	—	—	—	—	—
Euphausia frigida ♂	—	—	—	—	—	—	4	—	—
E. frigida ♀	—	—	—	—	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—
E. frigida, cyrtopia	13	3	2	—	—	—	64	—	—
E. frigida, furcilia	—	—	—	—	—	—	—	—	—
E. frigida, calyptopis	—	—	—	—	—	—	—	—	—
E. superba ♂	—	1	—	—	—	—	—	—	—
E. superba ♀	2	—	—	—	—	—	—	—	—
E. superba, immature	—	—	—	—	—	—	—	—	1
E. superba, cyrtopia	390	—	28	—	—	—	1012	—	—
E. superba, furcilia	26	—	—	—	—	—	—	—	—
E. superba, calyptopis	—	—	—	—	—	—	—	—	—
Thysanoessa vicina ♂	255	—	—	—	—	—	—	2	80
T. vicina ♀	238	—	—	—	—	—	—	15	176
T. macrura ♂	—	—	—	—	—	—	—	—	—
T. macrura ♀	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	—	3	—	—	50	—	—	—
Thysanoessa spp. immature	—	—	—	—	—	4	—	—	—
Thysanoessa spp. cyrtopia	—	12	15	—	—	—	—	2	—
Thysanoessa spp. furcilia	—	—	—	—	—	—	—	—	—
Thysanoessa spp. calyptopis	—	—	—	—	—	—	—	—	—
Limacina balea	—	—	—	—	—	—	—	—	—
L. helicina	—	—	—	—	—	—	—	—	—
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	—	—	—	4	—	—
Oikopleura	—	—	—	—	—	—	—	—	—
Fish juv.	1	—	—	—	—	—	—	—	—

j = juv.

time scale, etc., see pp. 252–62.

	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*	*R*
Beroë	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	28	18	13	6	8	18	—	—	—	—	—	—	—	—	—	—
Sagitta gazellae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	1	—	—	—	2	—	—	1	2	2	—	—	—
Calanus propinquus	—	—	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	35	127	22	282	180	205	3104	273	26	1038	276	1320	465	750	385	159	510
Primno macropa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	1	—	—	—	—	—	—	—	—	—	10	9	12	1	—
Cyllopus spp.	—	—	—	—	—	—	—	—	—	—	—	—	7	4	2	—	—
Amphipoda, *alia*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphausia frigida (immature)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
E. superba, adult	357	4	5	—	1	103	7084	1286	1	33	504	—	16	14,625	1730	2184	11,604
E. superba, immature	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Spongiobranchaea australis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	5	—	—	—	12	—	—	—	—	26	334	153	197	1	45
Fish juv.	1	—	—	—	6	1	20	6	—	3	3	2	6	3	—	—	—

	S	*T*	*U*	*V*	*W*	*X*	*Y*	*Z*	*AA*	*BB*	*CC*	*DD*	*EE*	*FF*	*GG*	*HH*	*JJ*
Beroë	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sagitta gazellae	—	—	—	—	—	—	—	1	—	—	1	4	2	—	1	2	—
Tomopteris spp.	—	2	—	2	2	12	1	7	2	6	6	12	15	—	2	6	2
Calanus propinquus	—	—	—	—	—	—	—	—	—	102	74	326	124	17	169	210	40
Pareuchaeta antarctica	—	—	—	—	—	—	—	—	—	—	1	1	3	—	—	—	—
Parathemisto gaudichaudi	420	1452	325	150	46	180	36	300	318	100	82	45	65	3	46	22	29
Primno macropa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vibilia antarctica	—	—	—	—	—	—	—	1	—	4	2	—	2	—	6	2	—
Cyllopus spp.	—	—	—	—	—	—	—	—	4	—	2	—	3	1	1	3	2
Amphipoda, *alia*	—	2	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—
Euphausia frigida (immature)	—	—	—	—	—	—	—	—	—	—	—	65	—	—	—	—	—
E. superba, adult	1419	7774	873	7758	535	9231	201	1441	7800	4042	1014	1239	22	24	1789	51	29
E. superba, immature	—	—	—	—	—	—	—	—	—	4	—	—	—	—	—	—	9
Thysanoessa spp.	—	—	—	—	—	—	—	—	—	10	3	—	12	—	—	—	—
Thysanoessa spp. immature	—	—	—	—	—	—	—	—	—	40	14	—	—	—	11	23	—
Spongiobranchaea australis	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	6	—	6	2	20	8	76	49	39	40	—	60	51	89
Fish juv.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

	KK	*LL*	*MM*	*NN*	*OO*	*PP*	*QQ*	*RR*	*SS*	*TT*	*UU*	*VV*	*WW*	*XX*	*YY*	*ZZ*	*AAA*
Beroë	—	—		No samples. Net damaged.		—	—	—	—	—	—	—	—	—	—	—	—
Ctenophora, *alia*	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—
Sagitta gazellae	1	4	—			—	—	—	—	—	—	3	—	—	—	—	—
Tomopteris spp.	5	2	1			5	7	3	—	6	—	—	1	—	—	—	—
Calanus propinquus	23	—	—			—	—	—	—	—	6	—	—	—	—	—	—
Pareuchaeta antarctica	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—
Parathemisto gaudichaudi	12	25	12			6	16	26	42	30	33	6	7	13	7	2	4
Primno macropa	—	—	—			2	3	—	6	—	3	3	1	2	1	2	—
Vibilia antarctica	2	2	2			2	4	16	30	9	18	9	7	—	1	4	—
Cyllopus spp.	4	3	2			2	4	10	6	3	30	—	7	1	1	1	—
Amphipoda, *alia*	—	1	—			—	—	—	3	—	—	—	—	—	—	—	—
Euphausia frigida (immature)	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—
E. superba, adult	5	14	95			45	54	29	9	135	6	3	—	2	—	—	—
E. superba, immature	2	—	—			—	—	—	—	—	—	—	—	—	—	—	—
Thysanoessa spp.	—	—	4			17	6	36	—	99	—	—	—	—	—	—	—
Thysanoessa spp. immature	—	9	13			112	—	150	—	—	—	18	—	5	—	—	—
Spongiobranchaea australis	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—
Salpa fusiformis	120	77, 14j	31			55, 29j	263	921	2235	1632	1614	483	46	41	122	33	—
Fish juv.	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—

j = juv.

Table V. Analyses of zooplankton samples collected in a series of twenty-three consecutive hauls with N 100 H nets, each towed for half a mile, at 0–5 m., in a continuous straight line at St. WS 53. The consecutive hauls are denoted by the letters *A*, *B*, *C*, ..., etc. For further details, time scale, etc., see pp. 252–62.

	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*J*	*K*	*L*	*M*
Beroë	2	18	7	31	—	41	1	3	—	—	2	19
Ctenophora, *alia*	—	—	—	—	1	—	—	—	—	1	—	—
Sagitta gazellae	—	—	—	—	—	—	—	—	—	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	—	—	—	—	—
Calanus simillimus	2	3	1	6	2	—	—	—	—	—	—	—
C. propinquus	11, 2j	37, 23j	41, 23j	39, 34j	60, 16j	15	23, 7j	3, 2j	4j	—	1, 4j	2, 1j
Pareuchaeta antarctica	—	7j	7j	119j	76j	27j	14j	50j	24j	146j	32j	32j
Parathemisto gaudichaudi	2	5	1	13	35	104	73	20	280	50	91	44
Vibilia antarctica	—	—	—	1	—	1	—	—	—	—	—	1
Cyllopus spp.	—	—	—	1	—	2	—	—	—	—	1	1
Amphipoda, *alia*	—	—	2	—	1	1	1	1	—	—	—	—
Euphausia frigida ♂	—	—	—	—	1	—	3	—	—	—	—	—
E. frigida ♀	—	—	—	—	1	1	4	—	—	—	—	—
E. frigida, immature	—	—	—	—	—	—	—	—	—	—	—	—
E. superba ♂	70	—	14	—	—	—	—	1	224	50	127	96
E. superba ♀	83	—	13	—	6	1	—	8	840	114	172	116
E. superba, immature	—	—	—	—	—	—	—	1	—	29	8	33
E. superba, cyrtopia	—	—	—	—	—	—	—	—	—	—	—	—
Limacina helicina	3	—	—	—	—	—	—	—	—	—	—	—
Salpa fusiformis	—	—	—	47	75	93	5	—	7	8	—	3

	N	*O*	*P*	*Q*	*R*	*S*	*T*	*U*	*V*	*W*	*X*
Beroë	4	—	—	1	4	1	—	—	—	—	—
Ctenophora, *alia*	—	—	—	—	—	—	1	2	—	—	—
Sagitta gazellae	4	—	—	—	—	4	2	1	—	—	—
Tomopteris spp.	—	—	—	—	—	—	—	2	—	—	—
Calanus simillimus	—	—	—	—	—	—	—	—	—	—	—
C. propinquus	8	12, 4j	1, 4j	8	—	4, 2j	—	—	—	—	1, 3j
Pareuchaeta antarctica	96j	—	2j	—	—	1j	—	—	—	—	—
Parathemisto gaudichaudi	300	92	51	12	12	4	12	2	10	5	35
Vibilia antarctica	—	4	—	4	—	2, 1j?	—	—	2	2	13
Cyllopus spp.	4	4	1	—	—	—	—	2	—	1	5
Amphipoda, *alia*	—	—	—	—	4	1	1	3	1	—	—
Euphausia frigida ♂	16	24	135	8	—	15	9	—	—	—	—
E. frigida ♀	24	28	126	8	—	1	—	—	—	—	—
E. frigida, immature	—	—	5	—	—	—	—	—	—	—	—
E. superba ♂	548	362	80	336	464	15	81	52	73	63	54
E. superba ♀	472	426	60	328	944	24	36	77	130	108	100
E. superba, immature	52	—	—	—	276	—	—	11	6	38	—
E. superba, cyrtopia	—	—	—	—	—	24	11	—	—	—	—
Limacina helicina	—	—	2	4	—	—	—	—	—	—	—
Salpa fusiformis	8	44	4	16	4	42	7	32	67	198	709

j=juv.

[*Discovery Reports. Vol. XI, pp.* 457–510, *Plates I–IV, December* 1936.]

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THE
CONTINUOUS PLANKTON RECORDER

BY

A. C. HARDY, M.A.

With an Appendix:

A TEST OF THE VALIDITY OF THE CONTINUOUS PLANKTON RECORDER METHOD

By A. C. Hardy, M.A. and Nora Ennis, B.Sc.

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THE CONTINUOUS PLANKTON RECORDER

By A. C. Hardy, M.A.

(Plates I–IV; Text-figs. 1–31)

INTRODUCTION

THE first Continuous Plankton Recorder was used on the R.R.S. 'Discovery' in the years 1925–7, and a brief note on its working was published during that voyage (Hardy, 1926). A second machine of improved design was made in 1929, to be followed by a number of others incorporating from time to time small modifications. It has now been used as a routine instrument both in the Antarctic on the R.R.S. 'Discovery II' and for the last four years in a general plankton survey of the North Sea on commercial steamship lines radiating from Hull. Whilst it may well undergo further changes, and lines of possible development are suggested here, it seems desirable that a full account should now be given of its construction, method of working and the advantages and limitations of the results obtained by its use. This is the object of the present paper; it will be followed, in an adjacent paper, by an account of the uneven distribution of oceanic plankton demonstrated by its use on the 1925–7 voyage. A report on the North Sea recorder survey is being prepared for publication elsewhere in collaboration with my colleagues at Hull: Dr G. T. D. Henderson, Mr C. E. Lucas, Mr J. H. Fraser and Mr K. M. Rae. A few examples of this work have already been published as illustrations to a brief account of this method of survey (Hardy, 1935). I am indebted to many people for technical assistance and encouragement during the development of the machine; acknowledgements will be made in different parts of the paper and in a section on p. 502.

PURPOSE OF THE MACHINE

Whilst working in the North Sea before joining the Discovery Expedition of 1925, I had been frequently impressed by the patchy distribution of the plankton.[1] In making an extensive survey by tow-net methods it is not always possible to place stations very close together; particularly is this so when making wide ocean traverses. An observer may doubt whether he is obtaining a true picture of the plankton distribution; he may at one point have taken observations within a concentration of zooplankton and between two other stations missed an important zone of phytoplankton.

---

[1] On one occasion (31 March 1922), when making a survey of post-larval herring and plankton in the Southern Bight, using the Petersen Young Fish Trawl and Nansen tow-nets at the surface, midwater and near the bottom, I decided to repeat the routine, so that four sets of observations were taken at one station instead of one set as at all other stations in the survey. The object was to test the validity of the methods employed in such a survey. The nets were used at 1900, 0700, 1430 and 1900 o'clock whilst the ship drifted in the surface current for 24 hours. Wind was negligible. The numbers of post-larval herring taken at the different times were 2448, 24, 7 and 341, and their average lengths were 25, 23, 22 and 26 mm. respectively. (The figures have already been published by Wallace, W., 1924. *Fishery Investigations* (England), Ser. II, VII, no. 4, p. 4.) The range of variation in the numbers caught at this one station was as great as that found for all the other thirteen stations of the survey: i.e. 2–793. (The stations were on an average about 20 miles apart.) The numbers of young sand eels and the volumes of zooplankton also showed con-

As a supplement to the tow-net used at intervals it seemed desirable to construct a machine which could be towed at full speed at any required depth below the surface and sample the plankton mile by mile so as to give a continuous record of the main changes in its composition along the line of tow. This is the purpose of the Continuous Plankton Recorder. It enables one to study the size, density and frequency of patches and to compare the irregularity of distribution in different areas. By having a continuous record of the changing abundance of the different species in the plankton community one may be able to detect ecological relationships between different species more readily than by observations at isolated stations; it provides one with a continuous line of ecological observation through the sea.

The recorder is not intended to supplant or to compete with the tow-net as a method of investigation, but rather to supplement it. On the other hand, it is possible by its use to carry out over a wide area surveys which could not be made by one research ship using tow-net methods. By employing several continuous recorders *simultaneously* on different commercial steamship lines across an area such as the North Sea it is possible to chart the broad changes taking place in the plankton month by month, or week by week, just as it is possible to chart meteorological changes if one has sufficient observations taken *at the same time* over a wide area.

The machine then has two main functions. Firstly it enables one to study in detail the changes in the composition of the plankton along a continuous line of observation, and secondly, if several are used simultaneously, they enable one to carry out broad periodic surveys using commercial ships. There are limitations to the method, as indeed there are to nearly all methods; since they are dependent upon the nature and working of the machine they will be discussed later (p. 498) when the machine has been described.

A number of modifications of these uses suggest themselves. The following have not yet been tried but are perhaps worth mentioning here to show the possible application of the recorder to other problems. When towed slowly the machine will sink by its weight to much greater depths than when towed at speeds of 6 knots and over (see p. 463). It could be used for a slow oblique haul, with altered gear ratios, to give a continuous

siderable variation at this one station. As the nets were taken at the surface, midwater and near the bottom, and the first and last set of samples were taken at the same time of the day (1900), vertical migration could hardly account for the differences found. They must be attributed to concentrations of post-larval fish and plankton being moved by the different rates of water flow of the lower water masses in relation to the position of the ship in the surface current. Such results would seem to point to the necessity of making observations on the patchiness in the distribution of different organisms before embarking upon a survey of their distribution by means of stations placed at considerable distances apart. In the 1926–7 'Discovery' survey at South Georgia the patchiness was investigated by series of consecutive nets (Hardy and Gunther, 1935, p. 255).

record of the gradations in plankton distribution from considerable depths to the surface. Instead of each inch or two of the record obtained representing a horizontal traverse of a mile or so of sea as at present designed, they could be made to represent a vertical scale of say 10 m. to the inch. Such hauls, repeated at different times of the day and at the same time on different days under different degrees of light intensity, *p*H, oxygen, phytoplankton, etc., should yield valuable data regarding vertical migration and the possible factors which govern it. Again, the vertical distribution and migration could be studied by several machines being towed horizontally and simultaneously at different levels. If such a series of recorders were towed continuously for a number of hours in a small circle, say of 1 mile diameter, the changes in the plankton at different levels could be recorded with the passage of time. If towed at approximately 6 knots, the completed circles, and so later determined fractions of the total obtained, would yield information as to the plankton at each level over approximately the same area for consecutive half-hour intervals. The recorder would be giving a continuous record in a time instead of in a space dimension. In relation to its use in a time dimension see also the section on possible developments in the machine design (p. 501).

GENERAL PRINCIPLES EMPLOYED

Before passing to a detailed description of the machine it may be convenient to describe briefly the general principles employed. Whilst the details of structure have from time to time been modified, the general principles have remained the same. The body of the machine (cylindrical in the first, but of rectangular section in the later models) has tapered ends giving it a general streamlined or torpedo-shaped form. At the front end is a small opening leading to a wider tunnel through which the water passes to an exit at the back as the machine is towed through the sea. A long banding of silk gauze is arranged to wind slowly across the flow of water in the tunnel. It winds off a spool placed below the tunnel, which it enters through a narrow slit; it is wider than the section of the tunnel, and its edges pass up in narrow recesses at the sides. It leaves the tunnel by a slit and at the same time is joined by another gauze banding winding off a spool placed above the tunnel. In passing across the water tunnel the gauze is supported behind by a grid-work of fine metal rollers. The tunnel is rectangular in section, and at the point where the gauze is situated the area of the cross-section is much greater than that of the opening in front, so that the flow of water entering the machine is slowed down and is approximately equal to the filtering capacity of the gauze. The gauze sieves out the plankton, which remains pressed against it by the flow of water until it is joined by the second gauze banding at its exit from the tunnel. The two bandings sandwich the plankton between them and are drawn between two driving rollers which grip the edges of the bandings tightly but do not press on the middle section of the gauze and thus do not damage the imprisoned plankton. From the driving rollers the two bandings pass together on to a storage spool.

The driving rollers are worked through a series of gears from a propeller which is situated on the *outside* of the machine, so that it is turned by the passing water as the machine is towed along. Thus the gauze bandings are wound on in direct relation to the distance travelled by the machine through the water; that which winds across the water tunnel and sieves out the plankton is ruled at equal intervals by transverse lines into a series of numbered sections. The space between these lines equals the distance from the bottom to the top of the water tunnel at the line of traverse. The pitch of the propeller blades may be adjusted, so that the speed at which the gauze winds on may be varied; thus one section may be made to pass across the water tunnel for approximately every 1, 2 or more miles of sea traversed, as desired. In practice the distance travelled by the recorder is read from the ship's log, so that when the number of sections exposed during the run is known the distance that each section represents can be easily found. The gears between the propeller shaft and the driving rollers bring about a reduction in rotation of approximately 6000 : 1. Each section is 2 in. across in the present machine (6 in. across in the first machine), so that for every mile by sea traversed 2 in. or less of gauze are wound on.[1] The storage spool has a capacity for a 250-section banding.

The storage spool, on which the two bandings with their imprisoned plankton are wound, is turned by a friction drive from the driving rollers. The drive to this spool is not a direct one for two reasons. Firstly, if direct, the speed of winding would increase as the diameter of the rolled up gauze increased and so would no longer bear a direct ratio to the passing water outside; secondly, if the storage spool alone wound on the gauze (instead of its being driven by the driving rollers) the roll would be wound so tightly that the plankton would be rubbed and pressed into an unrecognizable paste. By the device of the slipping friction drive the storage spool just takes up the slack on the gauze bandings as they are passed through from the driving rollers and winds them on without undue pressure.

The function of the second gauze banding, which joins the first after it leaves the water tunnel, is to imprison the plankton and prevent it being smeared from one section of the roll to another as it is wound up. In the first machine it also served another purpose: it wound off a spool in a tank containing strong formaldehyde, so that when it met the other fabric it was still soaked in formalin and killed and preserved the plankton. In the later models the storage spool itself is placed in a formalin tank, which the two bandings enter by a narrow slit kept all but closed by a flap of soft rubber. There is a slight but continuous loss of formalin through the slit when the machine is in the water, but this loss is made good by slow diffusion through small perforations at the bottom of the tank from an auxiliary tank containing formaldehyde. This arrangement will maintain a sufficient strength of formalin in the main tank during a 300-mile run.

The spools may be taken out and changed at the end of a run just as are the spools of a roll-film camera. The storage spool when taken out may be kept in formalin for any length of time before being worked up. In working up it is placed on a special microscope substage, so that the two bandings are separated over glass plates below a travelling microscope which enables the plankton to be counted section by section. The details of this process are described later on p. 491.

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[1] By fitting a larger propeller or altering the gear ratios one could adopt a larger scale of working, i.e. many inches to the mile.

Weight alone is not sufficient to take the machine far down below the surface when towed at speeds over 6 knots. The machine is therefore provided with a system of planes like a paravane or water kite; these, when it is towed, make it dive below the surface and swim horizontally at the desired depth. It is also furnished with a vertical tail fin. The exact arrangement of these planes will be described in the detailed account of the machine which follows: their size, angle of incidence, and position in relation to the centre of gravity of the machine must be exactly right to ensure stability at high speeds. As will be acknowledged later (p. 502) I have had invaluable assistance in this matter from the Admiralty. Between 8 and 16 knots differences in speed make little difference to the depth at which the machine swims. Its depth, within limits governed by the size of the diving planes, is determined by the length of the towing line employed. The machine takes up a position which is the resultant of the downward thrust of the diving planes and the backward thrust caused by the resistance to the water of the machine and its towing cable. With increased speed, within the limits above mentioned, both the downward and the backward thrusts increase together in approximately the same proportion. The depth to which the machine will descend for a given size of diving plane is not unlimited; a point is reached when so much cable is out that the backward thrust greatly exceeds the downward thrust and the machine will descend no further. If more cable is let out the machine will merely lie further astern; if greater depths are desired they must be attained by fitting larger diving planes (and employing a stronger cable to withstand the increased downward pull).[1]

In this general account of the principles employed the achievement of the desired result will appear simple, but in actual practice there have been many difficulties to be overcome. For this reason a detailed description of the latest machine is given later. So much depends upon the slits and plates in the water tunnel being exactly of the right dimensions, likewise on the position of the driving rollers, the right tension on the gauze bandings and devices for preventing the fabric adhering to the driving rollers. The mechanism of the later machines may appear at first sight to be unnecessarily elaborate, but each modification has been designed to overcome some cause of failure.

The method of towing and avoiding vibrational fatigue which may result in the fracture of the towing cable is described on p. 489. But an important principle in towing may be noted here. The towing head is placed above the body of the machine over the centre of pressure of the diving planes. The towing cable, which makes an inverted catenary curve in the water, descends to the towing head at a steep angle. This being so there is no disturbance in the water in front of the opening to the water tunnel which is at the extreme front of the streamlined body of the machine; the entrance to the water tunnel therefore cuts the virgin water cleanly so that the organisms are swallowed in the stream of water without warning. In the ordinary tow-net where the bridles and towing rope precede the entrance a number of the more agile animals may escape capture by darting aside at the approach of the ropes. This absence of obstruction is important with so small an opening.

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[1] This matter is referred to again on p. 489 where the methods of towing are described, and in Fig. 18 is given a graph from which the depth per length of towing rope may be determined for the Type II machine.

To sum up, the general principle of the mechanism may be compared with that used by the animal *Amphioxus* (*Branchiostoma*). The machine has a small opening leading into a larger cavity with an enlarged filtering surface. The size of the entrance can be adjusted and in the first machine, where it was larger than in later ones, there was a grid-work to keep out large objects. Instead of the plankton sieved out being carried off the "netting" by streams of mucus from the endostyle, the netting itself is made to move and carry the plankton with it. Just as the mucus collected in the epibranchial groove of *Amphioxus* carries the planktonic food in a continuous stream towards the oesophagus, so the gauze bandings carry the plankton continuously towards the storage chamber. Into this chamber is secreted, by narrow ducts from "a gland-like organ", a fluid: preservative instead of digestive. Only recently have I realized that my "invention" is but an imitation of Nature's mechanism.

THE FIRST MACHINE AND ITS PRINCIPAL DEFECTS

Before passing to the latest machine it will be convenient to describe briefly the first machine made, in order that the defects encountered may be put on record and so avoided by possible future workers who may design modifications of the machine.

External Features

The machine as first designed (Type I) is illustrated in Plate I. The main part of the body was cylindrical but tapered in front and behind to openings: the entrance and exit to the water tunnel. The tapered portion in front was shorter than that behind so as to give the body an approximate streamline design. Its total length was 4 ft. 2½ in., and the diameter of the cylindrical part 12½ in. The openings were 4½ in. in diameter, but the front one could be reduced to 3¾ in. and 3 in. diameter by screwing on metal collars. The front opening was also provided with a grid of crossing wires 1 in. apart to prevent the entrance of large objects such as fish; at times they cut jellyfish and *Pyrosoma* into neat cubes. The cylindrical body of the machine was cut in two towards its wider end and hinged below, so as to open and give access to the internal mechanism for adjustment and loading of the spools (Plate I, fig. 2). When closed the two parts were held tightly together below by the hinges and above by a pair of clamping pieces hinged on the forward part and fitted with screws bearing on lugs on the rear part (shown clearly in the plate). The propeller, with adjustable blades, was situated aft within a guard ring, and the propeller shaft passed forward into a gear box packed and kept filled with oil. The cap for replenishing the oil is seen in the photographs at the top of the gear box. The propeller shaft passed through a lignum vitae bearing placed between vertical fins and between two horizontal vanes which could be tilted up or down to act as elevators to adjust the stability of the machine. To the sides of the machine, fixed in cast brackets, were placed large triangular vanes at a downward angle, each vane being like half of a child's kite. These were the diving planes designed to give a downward thrust to the machine. Below the front of the body was a lead keel to bring the centre of gravity of the machine well forward. In its first form the recorder was designed to be towed from a shackle joining three chain bridles from three stout eyes, one on each side of the front end of the cylindrical body and one on the top of the cylinder towards its rear end. (In Plate I these chains are not shown, but the machine is hung for photographing from the above-mentioned eyes by wires.)

This design of planes had proved successful in a model but failed in the full-sized machine to give stability at speeds over 4 knots. In the completed machine the mechanism turned out to be heavier than was expected, with the result that the lead keel had to be larger than was originally intended to bring the centre of gravity sufficiently far forward. This enlarged keel being placed so far forward upset the lateral stability and made the machine veer sideways at high speeds. I then consulted Commander (now Sir Charles) Burney, the inventor of the paravane, who kindly put me in touch with the Department of Mine Design at H.M.S. 'Vernon', Portsmouth. From the staff of H.M.S. 'Vernon' I received invaluable help; stability tests were carried out and a new system of planes and fins designed which gave perfect stability up to speeds of 15 knots.

The modified Type I machine is shown in Plate II. The original planes, keel, and towing points were abandoned and in their place was fitted the following system. Below the front of the cylindrical body was placed a curved steel plane having a span of 36 in., breadth of 9 in., and angle of incidence of $12\frac{1}{2}°$. This was heavily loaded with lead. Above the part of the cylindrical body and over the centre of pressure of the plane just described was fixed the single point for towing: a shackle linked to an eye in a steel bar and frame connecting the old towing eyes. The small movable tail planes were replaced by much larger ones fixed horizontally. The vertical fin was greatly enlarged and fitted with a small movable inset rudder; above all this was fixed a large streamlined buoyancy chamber to give lift to the rear end of the machine which was very heavy on account of the internal machinery being placed so far back. This arrangement gave the machine a very ungainly appearance but remarkable stability in the water. Apparently the turning of the propeller tends to throw the machine slightly to starboard; this can be corrected by setting the inset rudder a few degrees to port.

Internal Mechanism

The arrangement of the internal mechanism will be best understood by reference to Fig. 1 and the photograph in Plate I where the machine is shown opened but unloaded, and in Plate II where it is loaded with a gauze banding ready for use. In this brief description the reader is assumed to have read the preceding section on general principles employed. The letters here refer to those in Fig. 1 which is a simplified diagram representing a longitudinal section through the machine. The water enters and leaves by the circular openings *A* and *B*, passing through a rectangular water tunnel made of sheet metal within the cylindrical body of the machine. Where the machine opens for the loading of the spools (at *X* above and hinged at *Y* below, see also photographs in Plates I and II) the two faces of the castings of the fore and rear parts fit tightly together below and at the sides of the water tunnel to prevent the escape of water, whilst above there is a narrow slit[1] to allow the passage of the gauze to the driving and storage rollers. The graduated gauze banding winds off the spool *C* placed below the water tunnel and leading round the small roller *D* passes through a slit and up across the water stream at *E*; here it is supported behind by a grid of fine rollers at *F*. The bottom of the water tunnel is hinged at *G*, and may be lifted up at *H* for loading the roller *C* when the machine is opened; this movable piece of the water tunnel is held in position by the clips at the side which may be seen in Plate I. The edges of the gauze banding pass up in recesses in the face of the forward casting, which just give sufficient clearance for the passage of a single thickness of gauze; the recess on the right-hand side is clearly seen in Plate I. The gauze banding after sieving out the plankton passes through a slit and up between the driving rollers *J* and *K*; in passing through the slit it is immediately joined by the second gauze banding which has wound off a spool *L* placed in a tank of formalin. The driving rollers *J* and *K* grip the edges of the two gauze bandings but do not press on the middle part imprisoning the plankton. The two bandings are now wound up on the storage spool *M*, which is driven by a chain and friction drive from the driving rollers (see general principles on p. 462). The driving rollers are turned slowly by a worm gear through the gear box *N* from the propeller *P*. The driving rollers are so situated that the gauze banding coming from the water tunnel presses against the back of the slit through which it passes, the slit being just wide enough to admit the passage of the collected plankton.

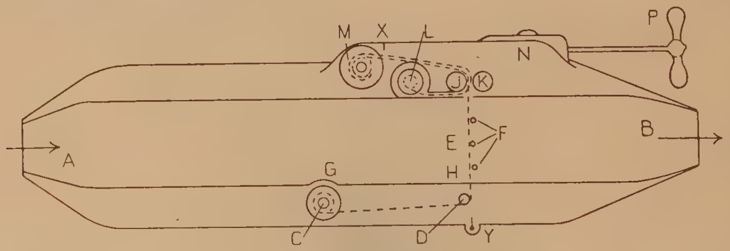

Fig. 1. Simplified diagram of the mechanism of the Type I Recorder.

Principal Defects in the Original Machine

In spite of many failures in the mechanism, this original machine, with the modified planes, successfully recorded some 2300 miles of plankton during the 1925–7 voyage of the 'Discovery' (Hardy, 1936). But the machine had many defects. It was too large and heavy, and with the added buoyancy chamber offered too much resistance to the water, necessitating the use of a very heavy towing cable. The spools had to be loaded and adjusted on the deck of the ship; this was a disadvantage in rough and cold weather, as very careful adjustments must be made to the tension on the gauze bandings (by means of brakes on the spools) and to the friction drive to the storage spool. With a rolling ship and polar temperatures such adjustments could only be made with difficulty. This is overcome in later models by making all these parts on a removable frame which can be loaded in the laboratory and subsequently fitted into the machine. The preservation device was not adequate, too much formalin being lost by diffusion (see new model, p. 469). Stoppages frequently occurred owing to the gauze bandings sticking to the driving rollers and being wound up on them; this was overcome by a comb-like device fitting into recesses in the roller (p. 469). The friction drive for the storage spool was a frequent cause of trouble. It consisted of a loose spindle passing through the spool, slotted so that it could be increased or reduced in diameter to hold the spool more or less tightly as desired; it was a simple but inefficient device (see improvement, Fig. 9). The driving rollers sometimes failed to grip the gauze sufficiently (see improvement, p. 469). A number of other minor defects which need not be detailed were put right during the course of the voyage. It may be noted that the power generated at the driving rollers is approximately $\frac{1}{8}$ H.P., so that pins, etc., used in securing parts of rollers must be of sufficient strength.

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[1] The flow of water through this slit is negligible, since it leads into a closed cavity when the machine is locked for towing.

THE LATEST MACHINE

It will be convenient to divide the account of the new machine into two parts, the first being a general description of its working and essential features and the second a full account of its detailed construction which will probably interest only those contemplating building similar machines. It will again be assumed that the reader has already read the section on the general principles employed (pp. 461–464).

The second machine (Type II) was similar in most respects to that about to be described. Eight machines of this type have been made. Improvements and modifications have been incorporated from time to time, and the description given below refers to the latest machine which may be termed Type II Modified.

GENERAL DESCRIPTION

In designing the new machine the defects already noted in the original model were kept in mind. It was desirable to make the machine as small and compact as was compatible with stability in the water and efficiency in plankton sampling. In the original machine the gauze bandings were 8 in. wide, 6 in. of which were exposed in the water tunnel; in the new machine the width of the gauze was reduced to 6 in., a width of 4 in. being exposed. Since the cross-section of the tunnel has to be rectangular, to match the rectangular sections on the gauze banding, considerable space was wasted in the first machine by making the outside body cylindrical. I decided to make the new machine rectangular in form. The latest machine is illustrated in Plate III and in Figs. 3–16. The rectangular cross-section in no way interferes with the stability of the machine; indeed it is likely that its vertical sides help to prevent lateral movement as do the side panels of a box kite. The main body was thus made as a box frame $6\frac{1}{2}$ in.

high, 8½ in. wide and 14¼ in. long; this contained the internal mechanism which could be slid out for adjustment and loading through doors opening on the left-hand side of the body. In front of this box section the body tapers to the opening of the water tunnel and behind it tapers to a point, the water exit being on the underside of this tail section. The total length is 3 ft. 4 in. The dimensions of the various parts may be read off from the scale drawings in the figures. By stout brackets, the diving plane is fixed below the body so that the leading edge is directly below the front end of the box section. Above is fixed a towing eye to which is attached a cylindrical shock absorber designed to reduce the vibrational fatigue on the towing cable (see p. 489). To the tapering tail section are fixed horizontal fins at the sides (continuous behind) and a large vertical fin above; in this vertical fin is inset a rudder which may be set to counteract any tendency to go to starboard due to the rotation of the propeller.

The propeller, with adjustable blades, is situated aft and is protected by a ring outside, a bar behind combined with a lifting handle, and by a pair of rods on each side connecting the ring to the front of the vertical fin. These guard rods were later additions found necessary to prevent fish, seaweed, etc., being caught in the propeller blades. On one occasion a dogfish was found decapitated and jammed in the propeller ring. The propeller shaft passes forward through a bearing, divides the vertical fin into two parts, and connects by a flexible joint with a drive shaft entering the gear box. The gear box, which is kept filled with oil, is situated in the top of the box body; in the illustrations its top will be seen projecting upwards as a dome furnished with a cap for replenishing the oil supply.

The opening to the water tunnel in front is 1¼ in. square, but may be reduced to 1 or ¾ in. square (or less) by fitting in small nose pieces. The tunnel widens out to a rectangular cross-section 4 by 1¼ in., where it joins the tunnel passing into the internal mechanism frame which can be slid out for loading. The movable section of the tunnel (i.e. in the mechanism frame) slides into grooves in the fixed part of the tunnel in front and behind and when closed makes a tight joint. The tunnel continues behind the movable frame to open beneath the tail section. All the space between the water tunnel and the tapering body wall of the front section is filled with lead to bring the centre of gravity of the machine as far forward as possible. The machine weighs 156 lb. (including the shock absorber), and the centre of balance (with the shock absorber removed) is 12½ in. behind the front of the machine (without nose cap). When first made the machine was fitted with a buoyancy tank in the tail section above the exit to the water tunnel, but this was found to be unnecessary.

Through the internal mechanism frame the water tunnel takes a slightly sigmoid path in the vertical plane in order that the minimum of space should be wasted in arranging the system of spools and storage tank. As it passes backwards the tunnel gradually widens to a cross-section 4 in. wide and 2 in. deep at the point where it is traversed by the gauze banding (see Fig. 10). In plan the tunnel is slightly asymmetrical on account of the mechanism frame having to be displaced to the left to allow space on the right for the worm drive from the gear box above (see Fig. 4) and the train of gear wheels. To have placed it centrally would have meant an increase in the width of the machine and wasted space on the left; the reduction in size and the resistance to the water are considered of great importance in a machine which may be used from commercial ships at speeds up to 15 knots. The movable frame holds all the mechanism except the gear box, which is fitted in the roof of the box body. When the frame is slid into position the worm from the gear box engages with cogs on a gear wheel on the right-hand end of the forward driving roller (Figs. 8, 11); this gear wheel engages with another on the rear driving roller which in turn drives a series of gears incorporating a special friction drive rotating the storage spool placed within a preservation (formalin) tank. In addition to the section, plan and elevations shown in Figs. 8–13, perspective drawings of the internal mechanism are provided in Figs. 14–16. The lettering is common to all these figures which are placed for more ready reference in the section dealing with the detailed description (pp. 472 to 488).

The graduated gauze banding winds off a spool *h* placed below the tunnel, passes back round a small roller *l* and up through a slit to traverse the water tunnel. In crossing the tunnel it sieves out the plankton and is supported behind by vertical bars and small horizontal rollers (Fig. 13). It leaves the tunnel by a slit and is immediately joined by the second gauze banding which has wound off a spool *g* placed above the water tunnel. The two spools, from which the bandings wind, rotate on spindles which may be slid out from the right-hand side to allow the removal of the spools; when loaded these spindles are held in place by a spring clip *i* on the right-hand side (Figs. 8, 14). The tension on the bandings may be adjusted by means of spring tongues *k* acting as brakes on the ends of the spools.

The two gauze bandings, having met, pass up together between the driving rollers *m* and *n* which grip them tightly at their edges by means of the blunt teeth on roller *n* pressing into the rubber ends of the other roller. These rollers only meet thus at their ends, leaving a gap between for the rest of their length to allow the plankton imprisoned between the gauze bandings to pass through without being unduly crushed. The bandings pass on together on to the storage spool *r* which is placed inside the tank *q* which is filled with a 20 per cent formalin solution. This spool may be removed by sliding out a spindle on the left-hand side after the removal of a cap which holds it in position. The storage spool is driven by the slipping friction drive (described in detail on p. 481), so that it just takes up the slack on the gauze bandings as they issue from the driving rollers (see general principles, p. 462). The bandings are lifted off the rear driving roller by a series of comb-like teeth which project from the lip of the entrance to the formalin tank, and fit into grooves in the roller (see Figs. 11, 13, 14). The lid of the formalin tank is lined with rubber which when closed by the rod *qo* makes a watertight joint at the sides and back; there is a narrow gap in front between the lid and the lip for the entry of the gauze bandings. The escape of formalin through this entry is largely prevented by the soft rubber lining to the lid extending out beyond the lid to press lightly on the incoming bandings. Nevertheless, some loss of formalin takes place when the machine is immersed in water; but this loss is made good by the slow diffusion of formalin through small perforations in the bottom of the tank from an auxiliary tank filled with cotton-wool and neat formalin (40 per cent formaldehyde solution placed below it on the right-hand side (Fig. 16, *qa*). The strength of formalin in the main tank will thus be maintained throughout a 24 hours run.

The internal mechanism frame is in two parts which may be partially separated from one another for the loading of the gauze bandings. It is divided along the line where the gauze crosses the water tunnel, and the two parts pivot one on the other about the driving rollers, but may be drawn a little way apart to allow the gauze bandings to be passed between the rollers (see Fig. 15). On each side of the forward part are hinged two long rods furnished at their extremities with wing nuts, which by engaging against slotted lugs on the rear part draw the two parts tightly together. When so drawn together the driving rollers tightly grip the gauze bandings as explained above, and a system of plates (see Figs. 12, 13 and 15) prevents the escape of water from the bottom and sides of the water tunnel.

The graduated gauze banding which sieves out the plankton is ruled with transverse lines 2 in. apart. Each section thus exposes an area 2 by 4 in. to the water stream and, the gauze banding being 6 in. wide, there is a 1 in. margin on each side of the water tunnel passing up in a shallow recess in the plates just mentioned. As already explained (p. 461) the force of the water through the tunnel keeps the plankton pressed against the gauze till it passes up through the exit slit to be joined by the second banding. The driving rollers are so placed as to press the banding against the back of the slit so that the plankton is not scraped off by its forward edge. The large exit behind ensures the water passing through the gauze (the opening to the tunnel in front, if an inch square, is only one-eighth[1] of the cross-section exposed to the gauze), and it cannot escape at the sides; a little water may escape through the narrow slits through which the gauze banding enters and leaves the tunnel, but this escape is negligible since the slits communicate with the closed space within the box body.

LOADING THE MACHINE

The internal mechanism frame is taken out for loading through the doors on the left-hand side of the machine. After pulling out the locking rods *qn* and *qo* the formalin storage tank is lifted out of the frame so that the auxiliary tank below may be filled with cotton-wool and formaldehyde. The tank is then replaced in the frame with the lid open. References may be conveniently made to Figs. 14–16.

The next stage in preparing the instrument for use is to wind on to the two supply spools *g* and *h* the gauze bandings, one plain and one graduated, the ends of which are secured to the spools by spring clips *ga* and *ha*. Winding may be carried out by hand, but this laborious and inefficient process can be avoided by using a special winding machine (similar in principle to a cinematograph film winder) which allows a much more even tension to be maintained on the bandings. The two spools are now secured in position in the mechanism frame (the graduated gauze below and the plain above the water tunnel) by inserting their spindles from the right-hand side and locking them in position by rotating the spring clip *i* till it presses on their ends.

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[1] Approximately one-fifth if the front opening is $1\frac{1}{4}$ in. square and approximately one-fourteenth if it is $\frac{3}{4}$ in. square. The latter opening is used as a standard in the present North Sea survey.

On disengaging the locking rods *e* and *e′* the two parts of the mechanism may be separated as far as the slots in the hinge plates *f* and *f′* will allow and swung open as in Fig. 15; the mechanism is now turned on its left side. The ends of the bandings are passed through their respective slits *gc* and *hc*, and the end of the graduated banding is drawn across the water tunnel to meet the end of the plain banding. The two ends are now passed together between the driving rollers *m* and *n* and the mechanism swung together (taking care that the graduated banding is not trapped when closing) and turned right way up. With the two parts together but not tightly closed the ends of the bandings are clipped to the storage roller *r* so that an even pull is ensured. The storage roller is then fitted into the main formalin tank by inserting its slotted spindle to engage with pins in the end of the spool and inside the gear wheel *qp* which drives it. A screw cap secures the spindles in place. Any slackness or bagging in the bandings is then taken up by rotating the supply spools *g* and *h*, after which the two parts of the frame are drawn tightly together by re-engaging and screwing up the locking rods. By means of a detachable winding handle fitted to the square section end of the forward driving roller *m* the bandings are wound on until the first section of the graduated gauze lies across the water tunnel. The main formalin tank is now filled with 20 per cent formalin and the lid closed and secured.

Great care must be taken before loading to ensure the required tension on the gauze by adjusting, if necessary, the brakes *k* pressing against the ends of the spools *q* and *h*, and also that the slipping friction drive *p* is correctly adjusted so that the storage spool just takes up the slack on the gauze bandings as they emerge from the driving rollers (see p. 499).

The frame is now ready for returning to the body. The edges of the water tunnel in front and behind are engaged with the edges of the water tunnel of the body castings which are machined to receive them. The frame is now pushed home until the gear wheel on the forward driving roller engages with the worm on the vertical shaft from the gear box. If the cogs on the gear wheel should fail at first to engage, the propeller shaft should be rotated until they do. The tongues *z* and *z′* (Fig. 8) are turned down to keep the frame in place; the doors are now closed and locked by the spring clips at the top and bottom.

THE GAUZE BANDINGS USED

Gauze bandings of different mesh may be used, but the standard gauze at present employed is Swiss silk bolting cloth, extra quadruple strength, 60 meshes to the inch, supplied by Messrs Staniar of Manchester. The bandings are 6 in. wide and usually cut into lengths to give rolls of 50, 100, 150, 200 or 250 sections according to the length of run required. 15 in. of gauze are left blank before the first section to allow for attachment to the storage spool and adjustment; 12 in. are left blank after the last section. As each section is 2 in. across the following lengths of silk sold by the yard are required respectively for the rolls above mentioned: $3\frac{3}{4}$, $6\frac{1}{2}$, $9\frac{1}{4}$, $11\frac{3}{4}$ and $14\frac{3}{4}$ yards. The makers supply the silk in rolls 40 in. wide, so that six lengths (6 in. wide) may be made from each length obtained.

The divisions may be ruled and numbered by hand, but much time may be saved by using the apparatus, shown in Fig. 2, which has been specially made to mark on the lines at the correct intervals by carefully rolling it along. As the roller rotates, the raised bars which mark the roll are in turn inked from an inking roller above the marking roller. The numbers can then be stamped on with a consecutive numbering stamp. Indian ink marks the rolls well and does not come off in sea water.

Gauzes of 40 and 100 meshes to the inch have also been successfully used. The possible use of an auxiliary roll of very fine mesh gauze alongside one of coarser mesh is referred to on p. 501.

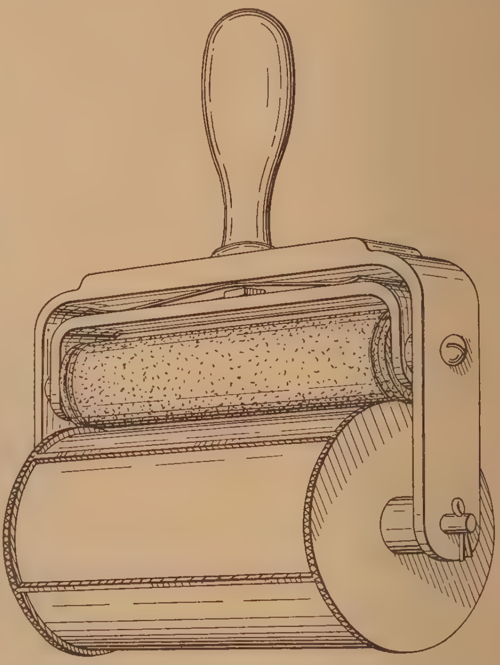

Fig. 2. Apparatus for marking divisions on gauze Recorder bandings.

DETAILED DESCRIPTION

A general account of the working and structure of the machine having been given, the detailed description will take the form of an explanation point by point of Figs. 3 to 16, in which all the structures are shown. Each structure, when shown in different figures, will always be given the same reference letter, and the description of the structures will follow the system of lettering in alphabetical order. See also Plates III and IV.

The machine consists of two main parts: the outer body and the removable internal mechanism. The reference letters allotted to structures forming part of the outer body will be shown as capitals; those referring to parts of the removable internal mechanism will be in small letters.

The outer body is built in three sections: the box-like central section which houses the internal mechanism and the tapering front and rear sections.

A. The tapering front section, the rear end of which forms the front of the central box section, is composed of a single casting carrying the water tunnel through its centre. The rear end of the casting is open and the water tunnel is supported by four webs *AB* (Fig. 5). The water tunnel in this section opens in front with an aperture $1\frac{1}{4}$ in. square and passes back for $1\frac{3}{4}$ in. before widening out sideways to a rectangular cross-section of 4 by $1\frac{1}{4}$ in. at the rear, where its walls above and below are machined to receive the water tunnel casting of the internal mechanism. Note that the water tunnel widens out asymmetrically to meet the tunnel of the internal mechanism, which is placed slightly to the left of the centre in order to accommodate the gear train on the right-hand side (see Fig. 11). The size of the front aperture may be reduced by fitting the nose-piece *W*. The space between the water-tunnel part of the casting and the outer-wall part is filled with sufficient lead to bring the centre of balance of the machine forward to the required point (p. 477) (Figs. 3–5).

B. The box-like central section is built up on a frame of $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{8}$ in. angle phosphor bronze connecting the corners of the rectangular parts of the castings *A* and *C*. It is covered on the top, bottom and right-hand side by plates of $\frac{1}{16}$-in. sheet brass; on the left-hand side are doors of the same material hinged at the sides, meeting in the middle and opening to allow the removal of the internal mechanism (Figs. 3, 4).

C. The rear or tail section is a tapering casting the front end of which is rectangular and forms the rear end of the central box section *B*. This rectangular part of the casting is closed except for an aperture 4 by $1\frac{1}{4}$ in. Formed on the casting in front of this aperture is a housing machined to take the rear end of the water tunnel of the internal mechanism and forming an exit for the water. Behind the rectangular front part the casting forms top and side walls for the tapering part which is open below. A horizontal deflector plate *CA* is fitted level with the top of the water-tunnel exit. Lugs *CB*, *CB′* are formed on either side of the casting to carry the horizontal tail fin (Figs. 3, 4).

D. The towing eye of phosphor bronze, secured to the front section casting *A* by seven $\frac{5}{16}$-in. steel bolts and nuts. The opening of the eye is $\frac{5}{8}$ in. internal diameter and its centre is $1\frac{5}{8}$ in. above the top surface of the central box section *B* and 7 in. behind the front of the machine (without the nose cap) (Figs. 3–5).

E, E′. Cast phosphor bronze brackets securing the diving plane *F* to the body. Each is secured to the casting *A* by three $\frac{3}{8}$ in. steel bolts and nuts and to the plane by one $\frac{1}{2}$ in. steel bolt and nut (Figs. 3–5).

F. The curved diving plane of $\frac{1}{8}$-in. steel having a span of $19\frac{3}{16}$ in., a width (chord) of 6 in. and an angle of incidence of $12\frac{1}{2}°$ (to the fore and aft axis of the machine). The leading edge is $2\frac{1}{4}$ in. below the front end of section *B*, and the rear edge 1 in. below the bottom surface of *B*. It is important to note that this plane is placed very slightly asymmetrically in that it extends $9\frac{11}{16}$ in. from the centre line to the right and $9\frac{1}{2}$ in. from the centre line to the left. This asymmetry gives a slightly different downward pressure on the two sides and counteracts the slight asymmetrical weighting of the machine due to the internal mechanism not being quite balanced about the central line but placed slightly to the left to accommodate the train of gear wheels on its right-hand side (Figs. 3–5).

G, H. The two sections of the vertical tail fin made of $\frac{1}{10}$-in. steel plate. They are separated to accommodate the propeller shaft *Q* which passes between them and are held together in front by the castings *I* and *I′*, and behind by casting *J* (Figs. 3–5).

I, I′. Castings securing the fin plates *G* and *H*, forming a tunnel opening through which the propeller shaft *Q* passes and base plates which are each secured to the casting *C* by two $\frac{1}{4}$-in. bolts passing through transverse slots. These slots in the castings *I* and *I′* allow, if necessary, an adjustment of the fin to act as a set rudder to counteract any tendency of the machine to go to port or starboard. This adjustment is only used when the correction afforded by the biasing rudder *L* is insufficient (Figs. 3, 4).

J. Casting securing the fin plates *G* and *H* behind and forming the housing for the bearing *O* for the propeller shaft. This is secured to the machined top surface of the casting *C* by three $\frac{1}{4}$-in. studs. At the top a boss is formed for accommodating the bolts securing its guards *M* and *N* (Figs. 3, 4).

K. Horizontal tail fin of $\frac{1}{8}$-in. brass plate, secured by three $\frac{5}{16}$-in. bolts on either side to lugs *CB* projecting from the casting *C* (Figs. 3–5).

L. Biasing rudder inset in vertical fin *G*, to which it is hinged in front. Its rear edge is furnished with a toothed rack *LA* which allows it to be set in any desired position and locked by the slotted plates *LB*, *LB′* (Figs. 3–5).

M. Guard ring round propeller, secured above to casting *J* and below on each side to the tail fin *K* at *MK* (Figs. 3–5).

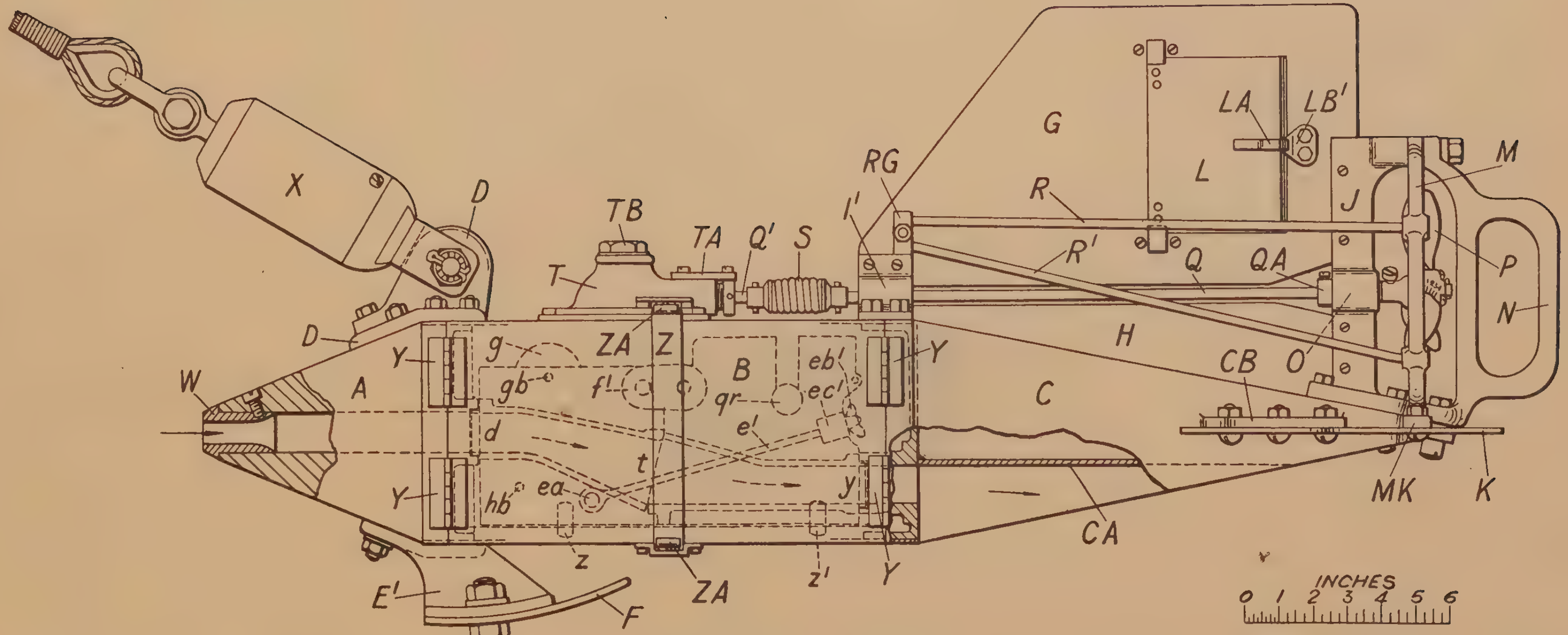
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Fig. 3. Scale drawing of the Type II Recorder seen in elevation from the left-hand side. The entrance to the water tunnel in front and its exit behind are shown in section. The internal mechanism frame and the path of the water tunnel are shown in broken line; this outline should be compared with the enlarged sectional drawing in Fig. 10. In this and the following figures the capital letters refer to parts of the outer body and the small letters to parts of the internal mechanism; each part is described in detail in alphabetical order in the text, pp. 472 to 488.

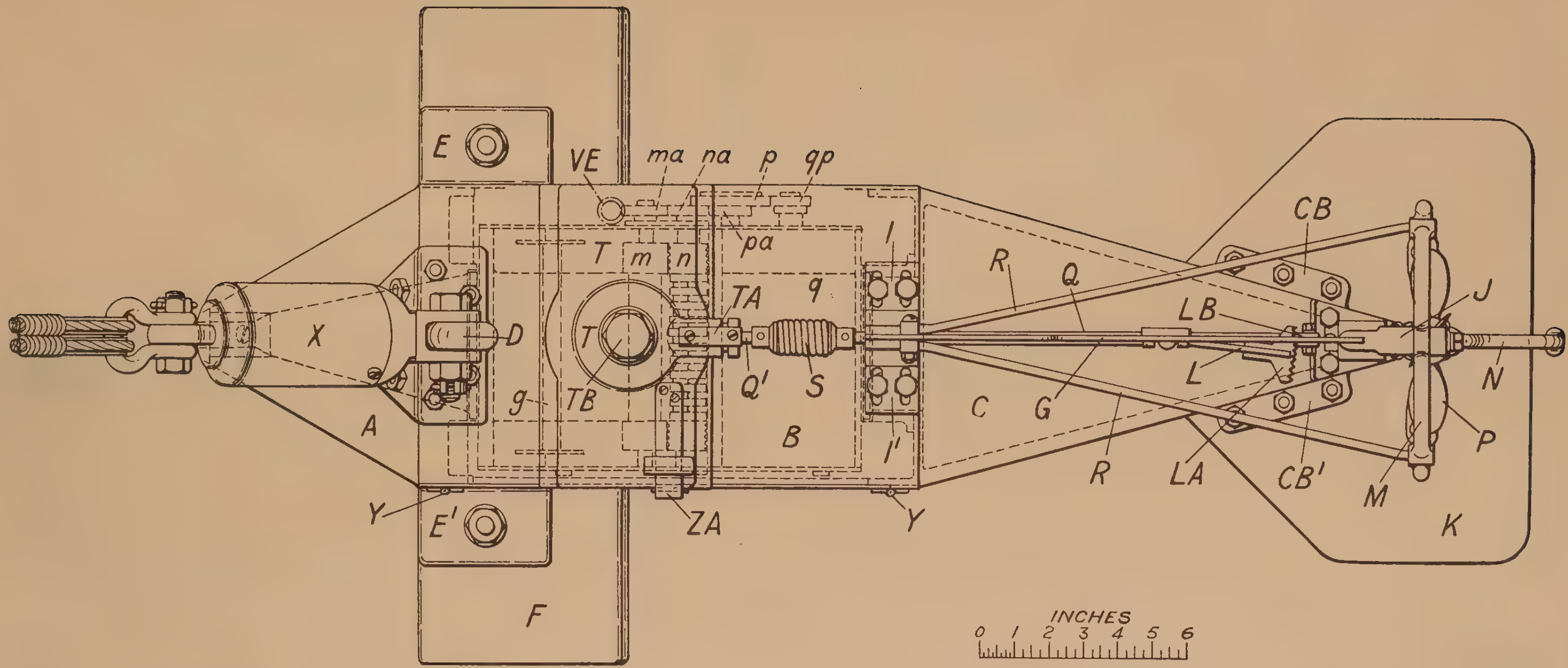
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Fig. 4. Scale drawing of the Type II Recorder seen in plan from above. The internal mechanism frame and the path of the water tunnel are shown in broken line. The reference letters refer to the detailed description in the text.

N. Rear propeller guard and lifting handle, secured at the top along with *M* to *J* and below to *C* (Figs. 3, 4).

O. Propeller shaft bearing of lignum vitae or special anti-friction metal (Tenaxus A1 Plastic metal) (Figs. 3).

P. The propeller (see Fig. 6) consists of three blades each $2\frac{3}{8}$ in. long from boss to tip and $1\frac{3}{4}$ in. wide at widest part. These are set in a cast central boss and each secured in position by a screw. By means of these screws they may be fixed at any desired angle, so that the pitch of the blades may be altered to give varying speeds of revolution in relation to the passing water, and thus a varying speed of winding to the gauze bandings in the internal mechanism. Each section on the gauze may therefore be made to represent one or more miles of sea traversed as desired.[1] A numbered scale is provided on the boss against each blade, so that each may be correctly adjusted by bringing an engraved line on the blade opposite a particular point on the adjacent scale. The boss is drilled to slide on to the propeller shaft to which it is secured by two set screws. The tail end of the propeller shaft is drilled to take a split pin which is inserted as a safety measure.

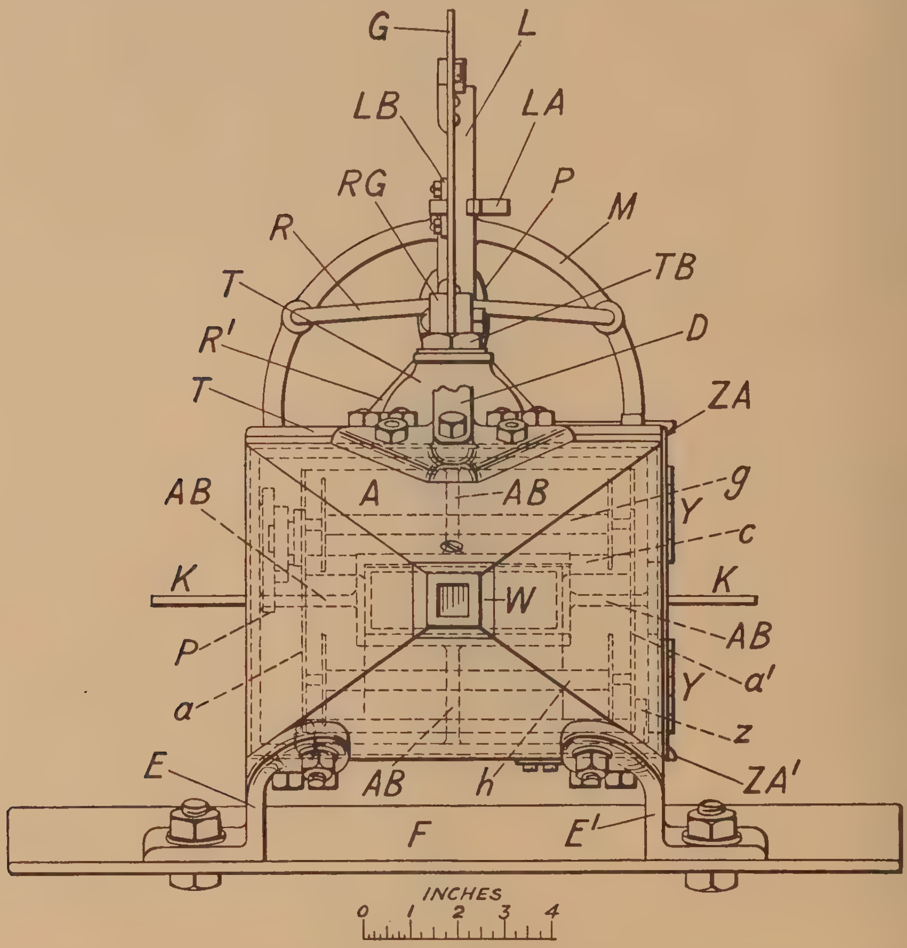

Fig. 5. Scale drawing of the Type II Recorder seen from in front with part of the towing eye *D* removed to show the details of the vertical fin assembly hehind. The internal details of the forward casting *A* and the internal mechanism frame are shown in broken line. For letter references see text.

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[1] See p. 495.

Q. Propeller shaft of $\frac{5}{16}$-in. diameter stainless steel, connected by *S* to *Q′*, which is a $\frac{1}{4}$-in. steel drive shaft to the gear box. *QA* is a stainless steel collar secured to the propeller shaft by set screws and situated in front of the bearing to resist the drag (Figs. 3, 4).

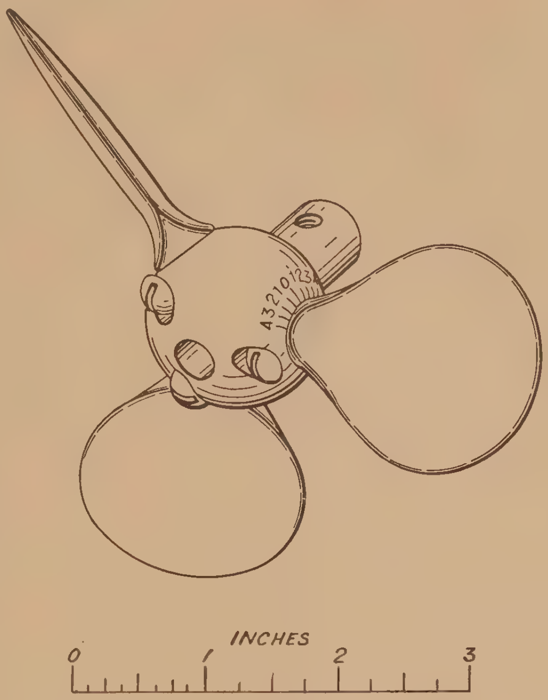

Fig. 6. The propeller removed from shaft.

R, R′. Rods, two on each side, secured to the ring *M* behind and to the vertical fin *G* in front at *RG*. These serve as guards to prevent objects such as fish, seaweed, etc., being caught in and jamming the propeller (see p. 468) (Figs. 3–5).

S. Universal joint of coiled spring type connecting the propeller shaft *Q* and shaft *Q′* (Figs. 3, 4).

T. Top half of gear box. This is formed of a casting extending from side to side[1] of section *B*, having a dome-shaped swelling, carrying a screw plug *TB* in its centre, covering the gearing and having at the rear the housing for the bearing of the shaft *Q′*. Incorporated with this bearing is an adjustable packing gland with a locking device *TA* (Figs. 3–5, 7).

U. Bottom half of gear-box casting carrying the gears and bearing for drive worm *VE* (Fig. 7).

V. Reduction gearing (see Fig. 7). *VA* is the primary driving worm secured to shaft *Q′* carried in bearings in the top half of gear box and having between it and the rear bearing a thrust ball race. *VB* is the primary gear wheel which is driven by *VA* and secured to a shaft carried in the bottom half of the gear box. Also secured to this shaft is the secondary worm *VC* driving the secondary gear wheel *VD*. This gear wheel *VD* is secured to a short vertical shaft which passes through the bottom of the gear box, in which is formed its bearing, and having secured to its outer end the worm *VE* which drives the gear train in the internal mechanism.

W. Nose-piece castings which may be fitted into the front of the water tunnel to reduce the opening to 1 in. square or $\frac{3}{4}$ in. square or any other size as desired and held by screw above (Figs. 3, 5).

X. Shock absorber or vibration damper to take up vibrations in the towing cable, see Fig. 17 and description on p. 489 (also Figs. 3, 4).

Y, Z. Hinges of the two doors on the left-hand side of the central box section. The forward door overlaps the rear door and is strengthened along its free edge by the metal strip *Z*. The doors are kept closed by this strip engaging with spring clips *ZA* and *ZA′* attached to the top and bottom of the central box section (Fig. 3).

Spring washers of appropriate metal are fitted under nuts where necessary.

The centre of balance, determined with the vibration damper *X* and nose cap *W* taken off, is $12\frac{1}{2}$ in. from the front of the machine. A variation of $\pm \frac{1}{16}$ in. may be allowed but not more.

The internal mechanism will now be described. It is illustrated in Figs. 8–16. The mechanism frame is made in two sections, front and rear, hinged about the rollers *m* and *n* (see Figs. 14, 15), and held together by the plates *f* and *f′* and the clamping rods *e* and *e′*.

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[1] The casting extends over the top on the left-hand side beyond the limits of the gear box. This is to give external symmetry which is of great importance in stabilizing the machine when towed at high speeds. The casting was originally asymmetrical, but modified after trials.

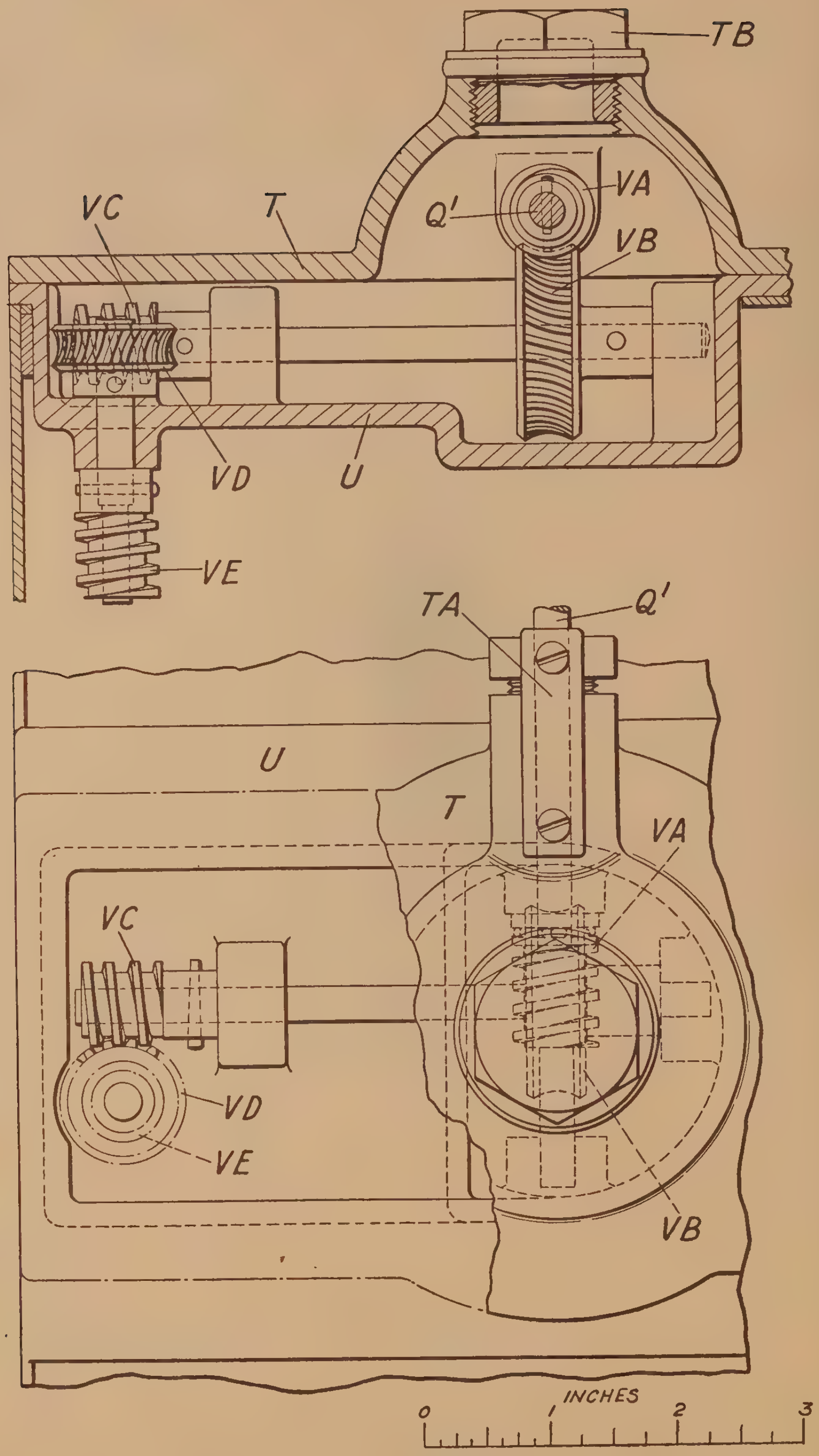
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Fig. 7. Transverse section and plan of the gear-box assembly.

a, a′. Right- and left-hand side walls of the front section of the mechanism frame: 0·09-in. sheet brass, dull nickel plated.

b, b′. Right- and left-hand side walls of the rear section of the mechanism frame. Same material as *a*, *a′*.

c. Cross-bar holding together *a* and *a′*, and passing above and cast in one with the water tunnel.

d. Forward entrance to the water tunnel through the internal mechanism frame; its edges slide into the machined edges of the water tunnel of the casting *A* (Fig. 3). The tunnel walls are of cast phosphor bronze.

e, e′. Clamping rods, one on each side, serving, when tightened up, to hold the two sections of the frame together. They are hinged to the side walls of the front section at *ea* and provided at the other end with wing nuts *eb*, *eb′* to engage with the slotted lugs *ec*, *ec′* on the rear section.

ea. Hinge pins for clamping rods *e*, *e′*; these also secure the side plates *a*, *a′*, to the cross-bar *s*.

eb, ec. See under note *e*, *e′*.

f, f′. Plates, one on either side, fixed to the rear part of the frame about the bearing for the spindle of the roller *n* and having slotted ends to accommodate the bearing carrying the spindle for the roller *m*. These plates act as a hinge about which the two parts of the frame may be swung open when the ends of the rods *e*, *e′* have been released. The slots allow the two parts of the frame, and so the rollers *m* and *n*, to be pulled $\frac{1}{16}$ in. apart to allow the gauze bandings to be threaded through the driving rollers.

g. Spool from which plain gauze banding winds.

ga. Metal strip for securing end of gauze banding to spool *g*.

gb. Spindle on which the spool *g* rotates; it is provided with a milled head by which it may be drawn out on the right-hand side when the spring clip *i* is rotated, thus allowing the removal of the spool.

gc. Slit through which the plain gauze passes to join the graduated gauze above the water tunnel.

gd, gd′. Path of the plain gauze.

h. Spool from which graduated gauze banding winds.

ha, hb. Similar to *ga* and *gb* but referring to spool *h*.

hc. Slit through which the graduated gauze passes up to cross the water tunnel.

hd, hd′. Path of the graduated gauze.

i. Spring clip which holds spindles *gb* and *hb* in position; this may be rotated about the pin *j* to release spindles (see under *gb*).

j. Pin about which *i* rotates.

k, k′. Spring tongues bearing on the end-plates of the spools *g* and *h* to act as brakes. They may be bent by hand to adjust pressure.

l. Metal roller $\frac{5}{16}$ in. diameter round which the graduated gauze banding turns before passing through the slit to cross the water tunnel.

la, la′. Bearings, on either side, for roller *l*.

m. Forward driving roller of rubber (vulcanized to brass spindle) with central section 4 in. long by 1 in. diameter and end-sections each 1 in. long by $1\frac{1}{4}$ in. diameter between which and the metal-toothed ends of the driving roller *n* the gauze bandings pass.

ma. Gear wheel $1\frac{3}{8}$ in. diameter rotating freely on the spindle of roller *m* and transmitting drive from the worm *VE* to the gear wheel *na* secured to the spindle of the rear driving roller *n*. This gear wheel *ma* is kept in place on its spindle by a small pin passing through the square section *mb* of the end of the spindle. (Originally this gear wheel was secured to its spindle by a taper pin; this pin was discarded as it was found that the gauzes in practice fed better if the forward roller was left to rotate freely.)

mb. Square end of spindle of roller *m* for the attachment of a winding handle to rotate the rollers in loading and adjusting bandings for use.

n. Rear driving roller of plated brass with central section, 4 in. long by $1\frac{1}{4}$ in. diameter, recessed to accommodate ten comb teeth *gh* (diameter of recessed portions being 1 in.) and with toothed

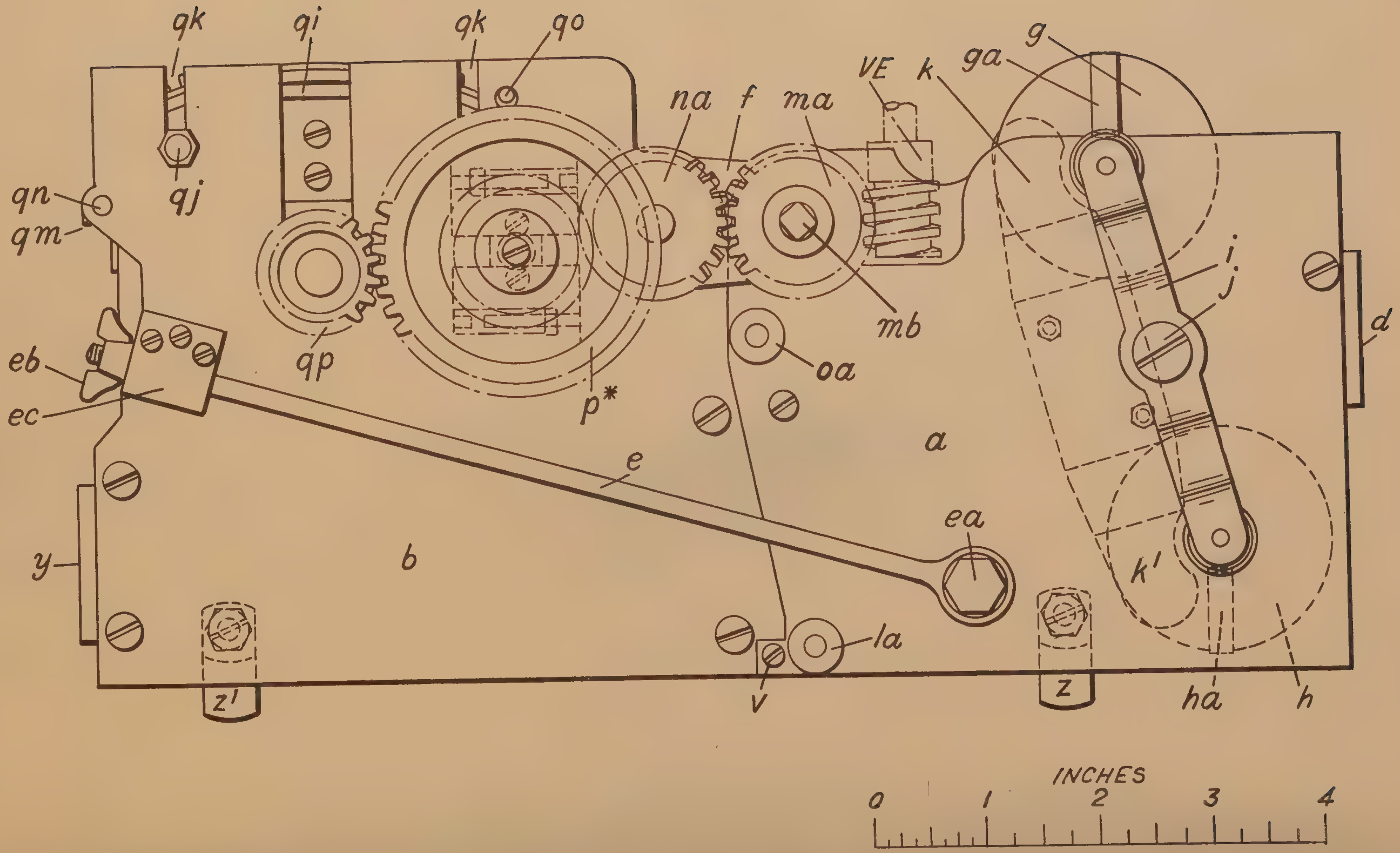
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Fig. 8. Scale drawing of the internal mechanism frame seen from the right-hand side, *d* and *cj* being the entrance and exit to the water tunnel respectively. For letter references see text.

metal end-sections, 1 in. long and 1$\frac{5}{16}$ in. overall diameter. Between these and the rubber ends of roller *m* the edges of the gauze bandings are tightly gripped (when the two parts of the frame are screwed together by the wing nuts *eb*, *eb′* and driven forward when the rollers are rotated.

na. Gear wheel, 1$\frac{3}{8}$ in. diameter fixed to spindle of driving roller *n*, driven as described under *ma*, and engaging with the gear wheel *pa* of the friction drive system for the storage spool (see Fig. 9).

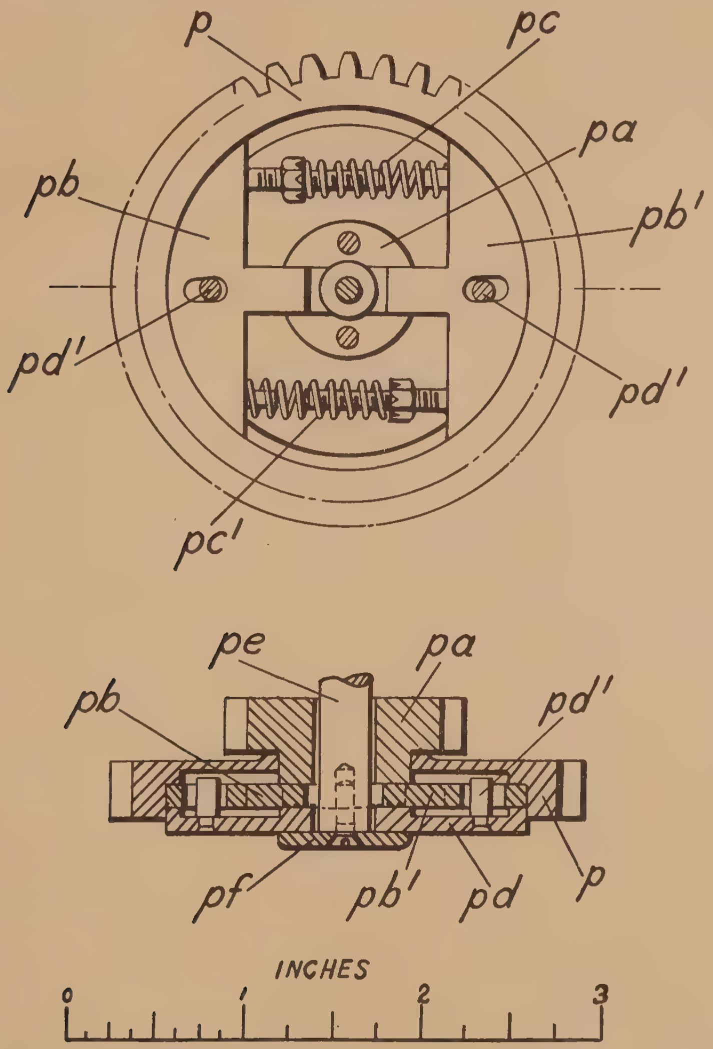

Fig. 9. Details of the large gear-wheel containing the friction drive system for driving the storage spool: elevation, with the covering plate removed, and section. For letter references see text.

o. Metal roller $\frac{7}{16}$ in. diameter round which plain gauze banding turns before passing through slit to join the graduated gauze.

oa, oa′. Bearings, on either side, for roller *o*.

p. Large gear wheel containing the friction drive system for driving the storage spool (see Fig. 9).

pa–pf. The small gear wheel *pa* is driven through the gear train (see under *na*) and forms the driving member of the clutch; it is slotted at its outer end to engage with the driving projections of two shoes *pb*, *pb′* which drive the large gear wheel *p* by their friction on its inner surface. These shoes are kept in contact with the inner surface of the gear wheel *p* by two coil springs *pc*, *pc′* located

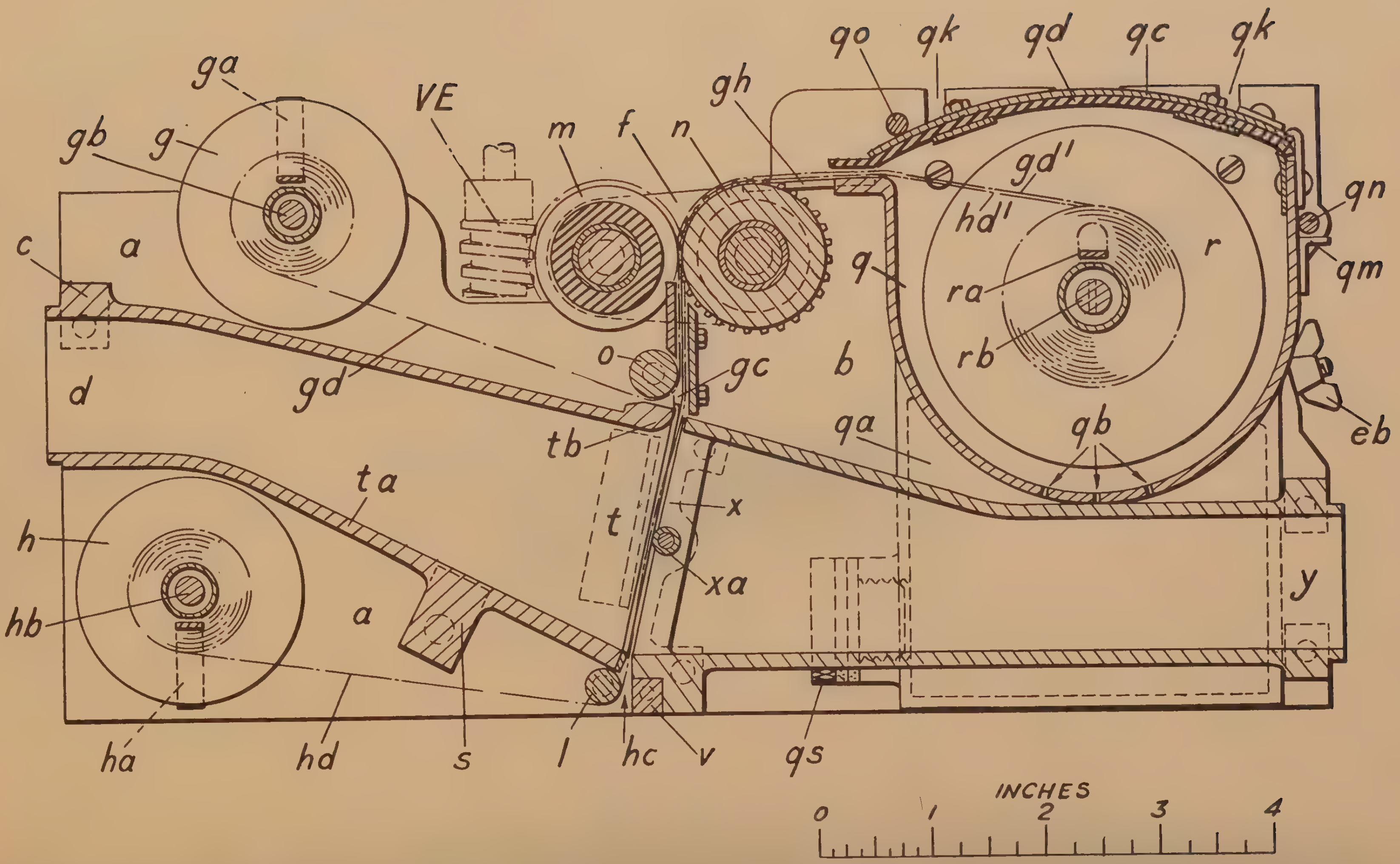
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Fig. 10. Optical section of the internal mechanism frame drawn looking *towards* the right-hand side, *d* and *g* being the entrance and exit of the water tunnel respectively. The paths taken by the two gauze bandings are shown as *gd*, *gd'* and *hd*, *hd'*. For further letter references see text.

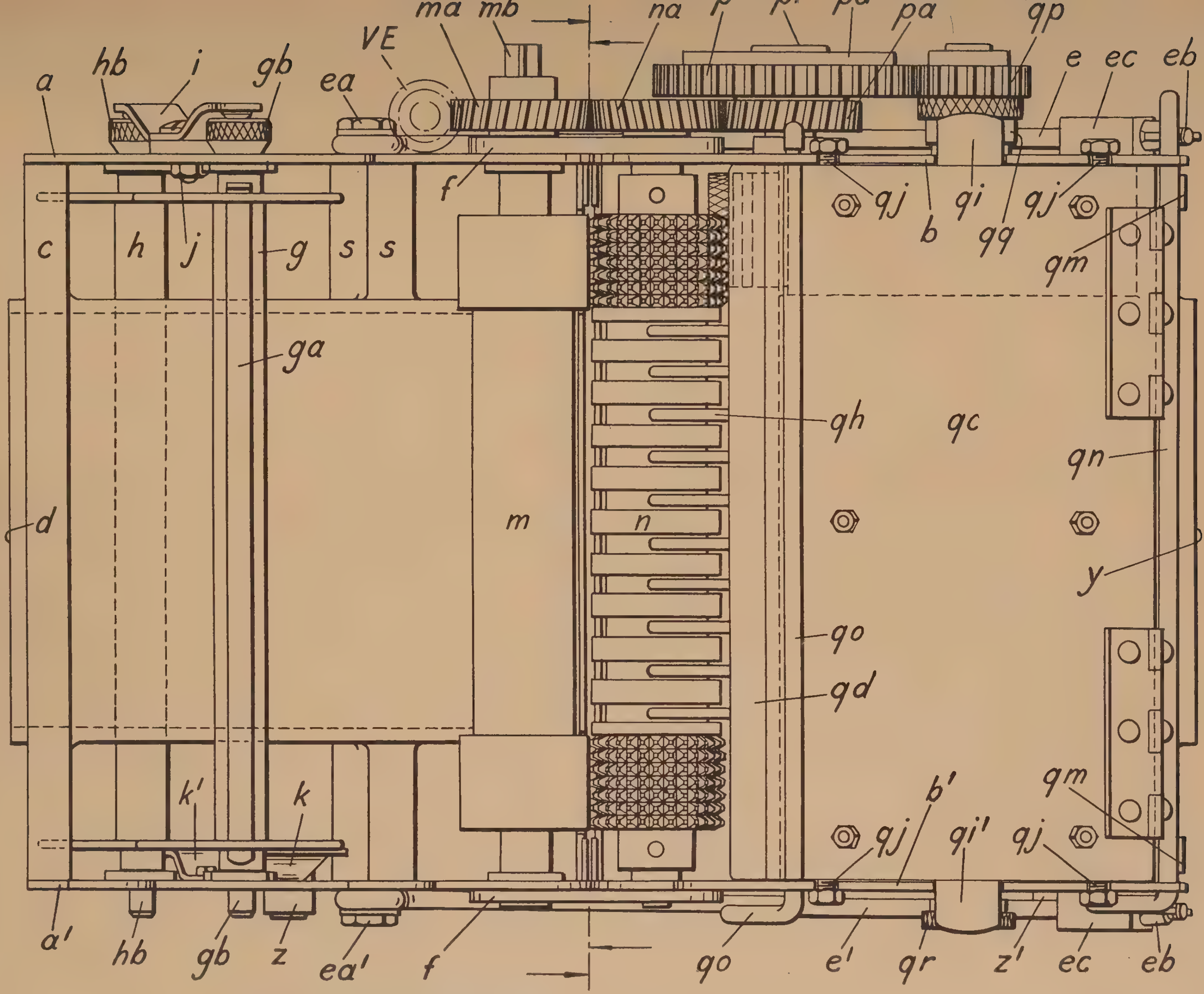
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Fig. 11. The internal mechanism frame seen from above and drawn to the same scale as Fig. 10.

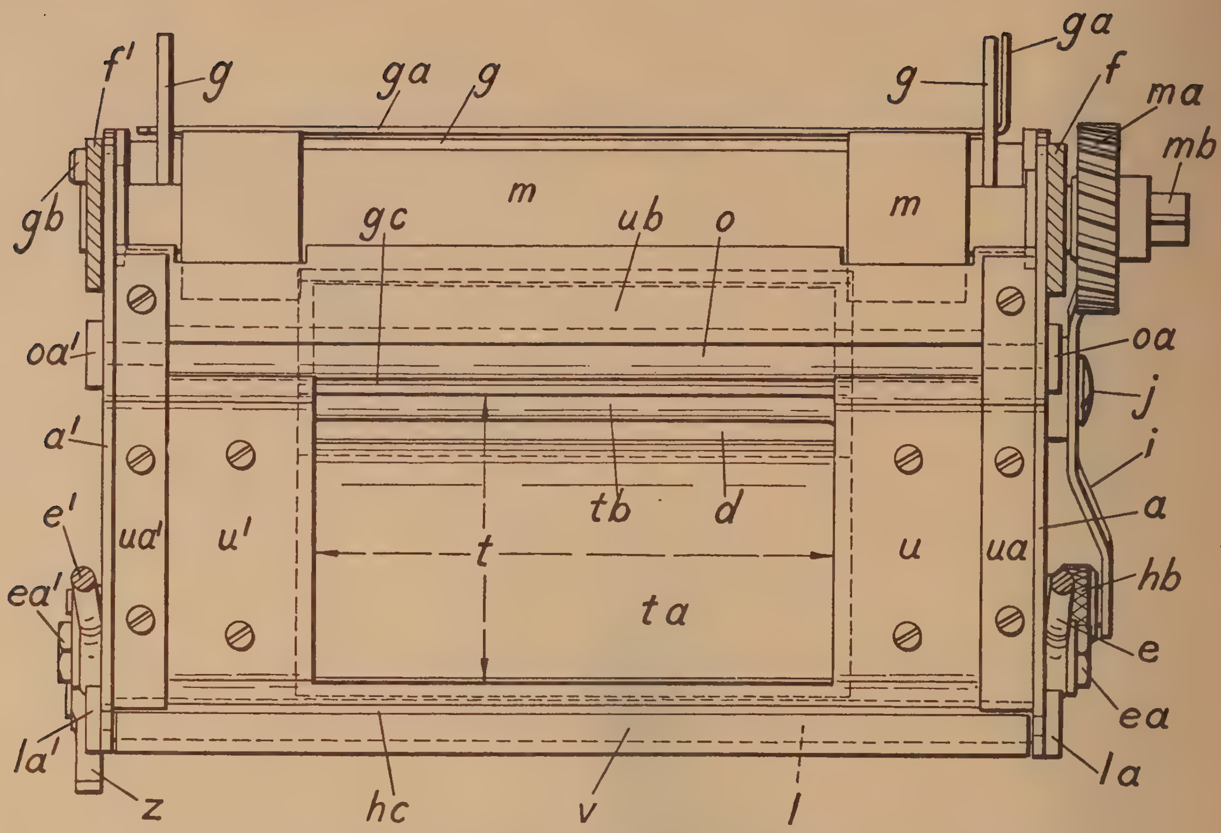

Fig. 12. The internal mechanism frame is in two parts linked and hinged together by the plates *f* and *f'* and pivoting about the rollers *m* and *n* (see Fig. 15). This figure, and Fig. 13 opposite, represent elevations of the two interlocking faces of the two parts drawn to the same scale; above is shown the forward section looking towards the front. For letter references see text.

on pins and provided with an adjustment for tensioning. A plate *pd* is secured to the driving gear wheel *pa* to cover the mechanism and is provided with two pins *pd'* which assist in locating the shoes. The large gear wheel *p*, the driven member, engages with the gear wheel *qp* on the formalin tank, so rotating the storage spool within the tank. The whole assembly, *pa–pd*, is carried on a short shaft *pe*, secured to the side frame of the mechanism, about which it rotates freely. A washer *pf*, secured to the shaft *pc* by a set screw, retains the friction assembly on the shaft.

q. Formalin tank, cast phosphor bronze and dull nickle plated, containing storage spool *r*.

qa. Reserve tank for formaldehyde, cast in one with *q* and communicating with it by six fine perforations *qb*.

qb. Position of perforations connecting *qa* with *q*.

qc. Curved metal lid, 0·07 in. thick, lined with rubber and hinged to *q*.

qd, qe. Rubber lining *qd* held to lid of formalin tank by two strips of plated brass *qe*.

qf. Lip to entrance of formalin tank through which the gauze bandings pass to the storage spool. Note that the lip is just lower, 0·05 in., than the edges *qg*, which are continuations of the sides of the tank. Thus a narrow slit is left for the passage of the bandings between the lip and the soft rubber lining which extends beyond the lid and rests lightly on the bandings, so minimizing the escape of formalin.

qh. Comb teeth, 0·175 in. wide and 0·065 in. thick, on lip of formalin tank; these fit into grooves in the rear driving roller *n* and lift the bandings clear of the roller (see reference on p. 467 to difficulties with the Type I machine).

qi, qi'. Lugs for lifting the formalin tank out of the mechanism frame.

qj, qk. Locating pins *qj*, sliding in slots *qk* in the mechanism frame.

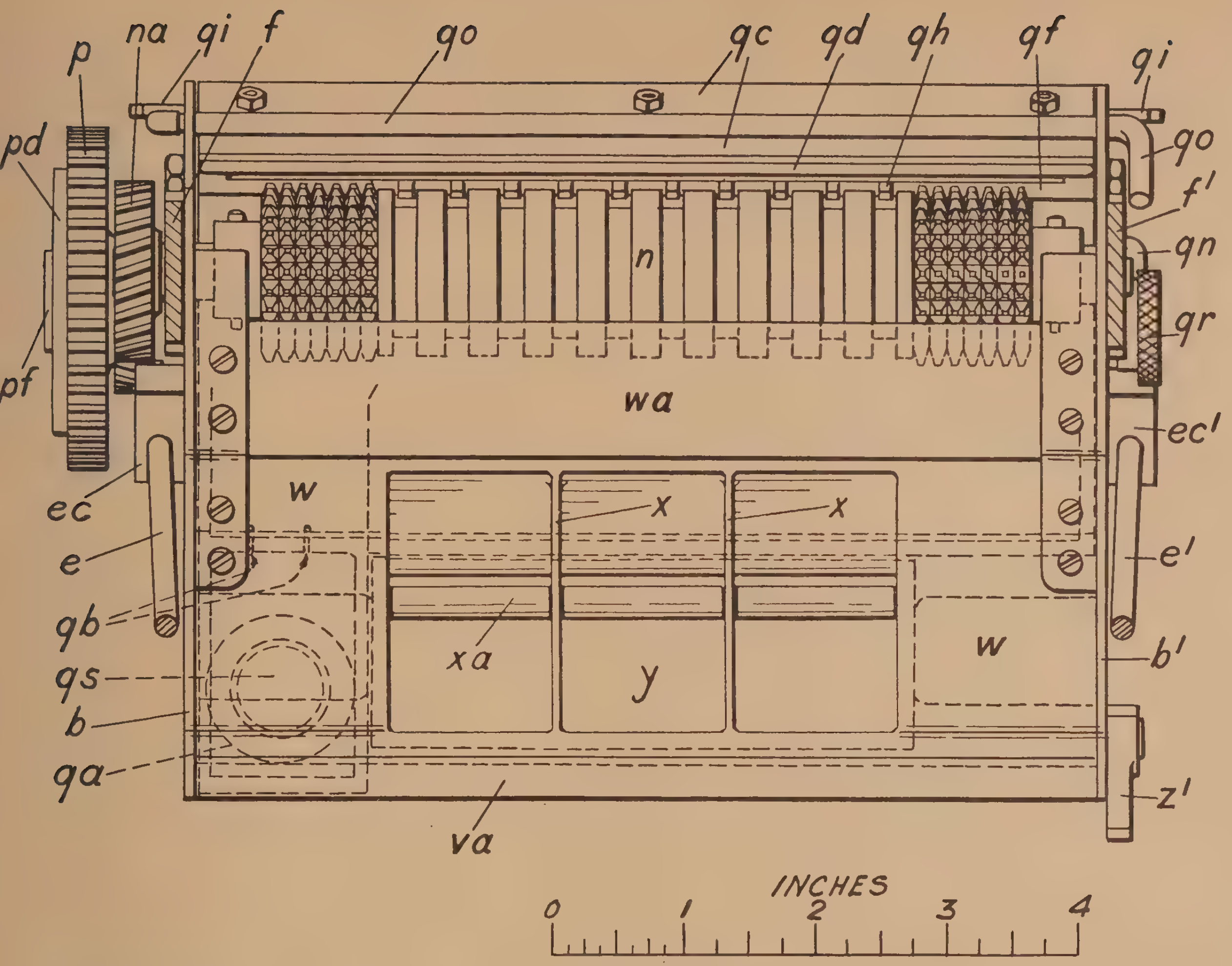

Fig. 13. Elevation of the rear section of the internal mechanism frame looking towards the back and showing the face which interlocks with that of the forward section shown in Fig. 12. For letter references see text.

qm, qn. Small brackets *qm* acting as tongues against which the locking rod *qn*, passing through mechanism frame, rests and holds tank in position in frame.

qo. Rod passing through side walls of frame and pressing on the lid *qc* of formalin tank and so keeping it tightly closed.

qp. Straight-toothed gear wheel engaging with friction drive *p* and so rotating storage spool within tank.

qq. Packed bearing carrying storage-spool spindle.

qr. Screw cap securing the spindle *rb* for the storage spool *r*, in the tank. On removing the cap the spindle may be withdrawn and the spool lifted out of the tank; when in place a slot in the end of the spindle engages with a pin across the bored out centre of the gear-wheel assembly *qp*.

qs. Screw cap for filling reserve tank with formaldehyde.

r. Storage spool, see note under *qr*.

ra. Strip of metal securing the end of the gauze bandings to the spool **r**.

rb. Spindle for storage spool *r*, see under *qr*.

s. Cross-bar holding together *a* and *b*, cast in one with and supporting the water tunnel.

t. Cross-section of water tunnel covered by filtering surface of graduated gauze banding. In Fig. 11 the floor of the tunnel is seen through *t*.

ta. Floor of water-tunnel casting.

tb. Curved edge of water-tunnel opening. Note that it ends $\frac{1}{32}$ in. below the surface of the plates *u* and so leaves a gap, up which the plankton passes on the gauze, to be imprisoned by the second gauze banding coming through the slit immediately above the top of the water tunnel.

u, ua. The plates *u*, *u'*, against which the edges of the graduated gauze banding pass up, are $\frac{1}{32}$ in. below the plates *ua*, *ua'* which when the frame is closed press tightly against the face *w* of the hind-section of the frame. This arrangement allows a narrow recess to take the thickness of the gauze banding.

ub. Plate above the slit *gc*.

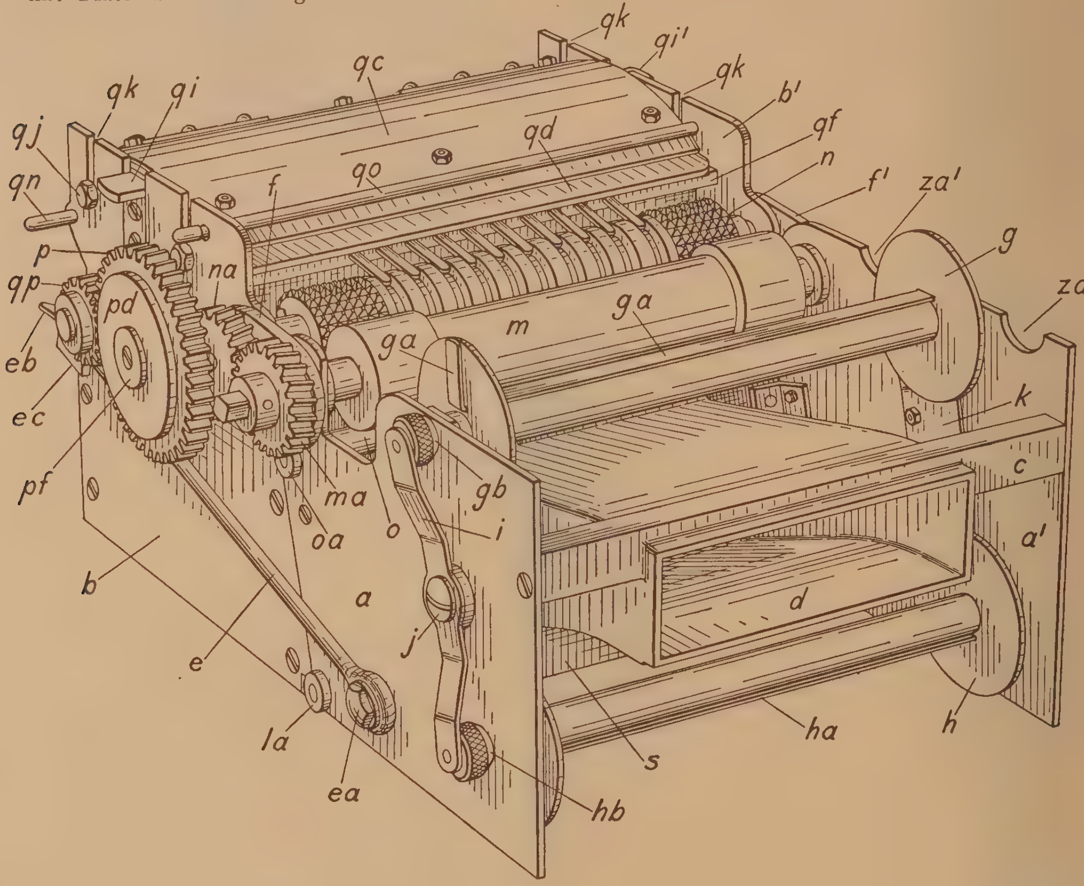

Fig. 14. Perspective drawing of the internal mechanism frame seen from the right front with the two parts locked together by the clamping rods *e* and *e'*. For further letter references see text.

v. Cross-bar making close joint with the recess *va* at the base of the face of the hind-section, so locating the two sections of the mechanism frame and sealing the gap in the water tunnel except for the narrow slit through which the gauze banding passes.[1]

va. Recess into which fits the bar *v*.

w. Face cast in one with hind-section of the water tunnel.

wa. Plate continuous with face *w*.

x, x'. Vertical bars crossing section of water tunnel and holding *xa*.

xa. Horizontal rollers on fine spindles between the bars *x*. The function of the bars and rollers is to give support behind the gauze banding which passing up in front of them is subjected to the pressure of the water flow through the tunnel.

y. Exit from water tunnel.

[1] See footnote on p. 466; the same applies to this type II machine.

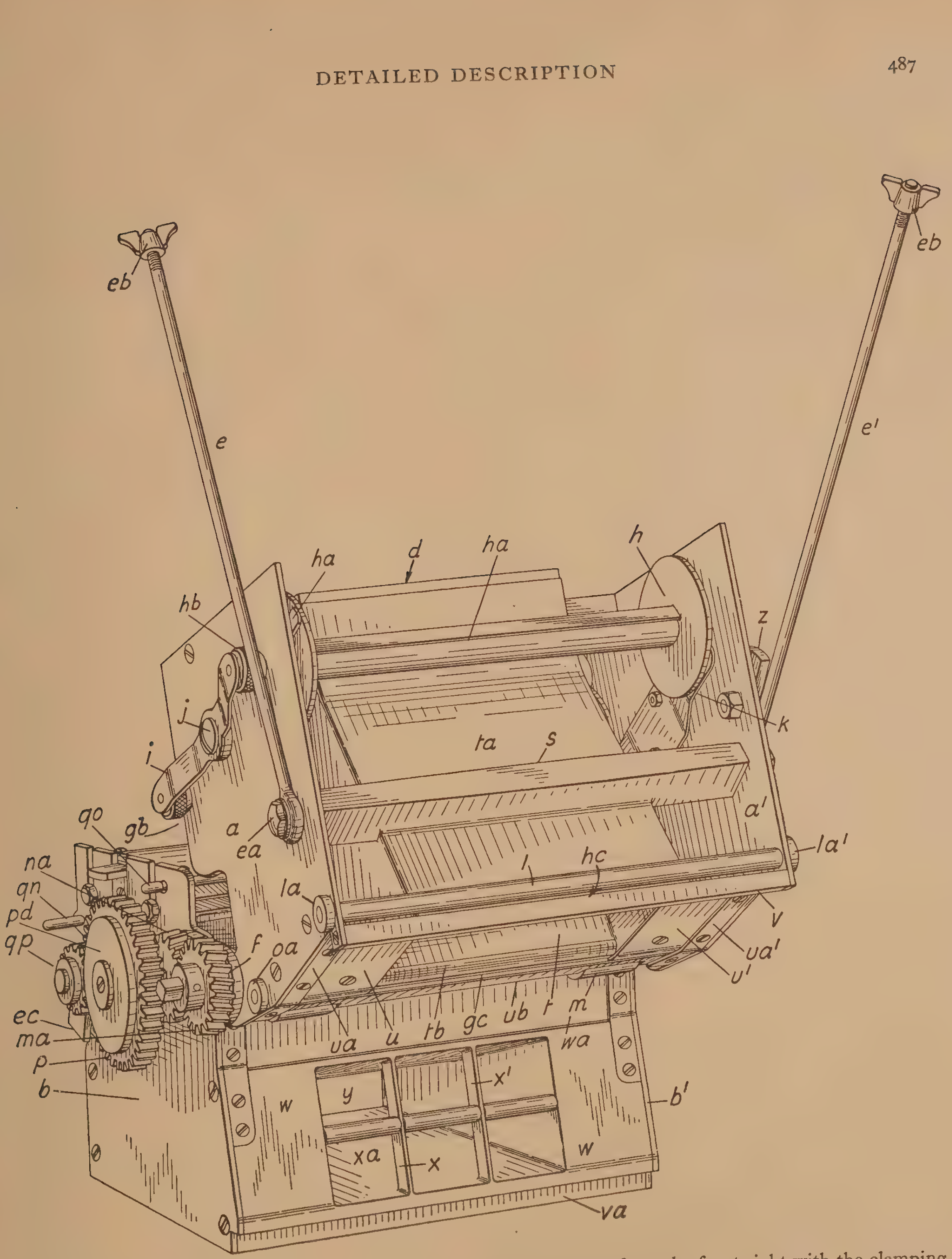
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Fig. 15. Perspective drawing of the internal mechanism frame seen from the front right with the clamping rods *e* and *e'* released and the two parts of the frame swung open about the hinge plates *f* and *f'* ready for loading the gauze bandings. For further letter references see text.

z, z′. Pivoted locking tongues which secure the mechanism frame in position within the box section of the outer body. When turned down they engage behind the bottom angle brass frame of the box section in the left-hand side just inside the doors.

za, za′. Cutaways in the frame on the left-hand side to form finger grips for withdrawing the mechanism. There is also a circular hole, shown in Plate III, fig. 2, towards the base of the frame *b′* which serves a similar purpose.

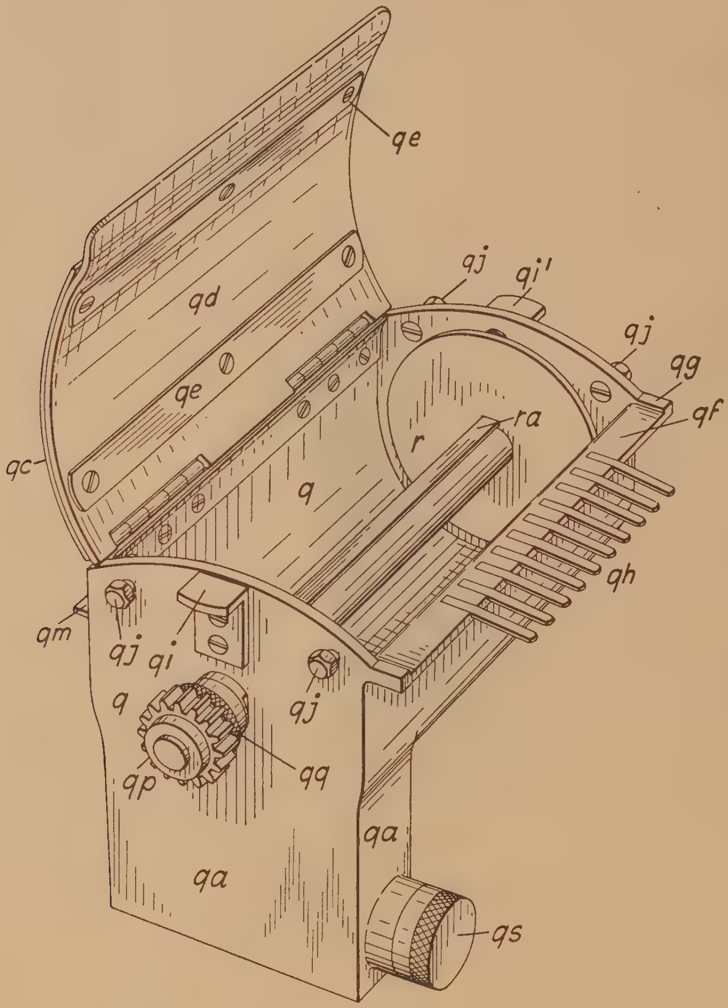

Fig. 16. Perspective drawing of the formalin tank with the lid opened to show the storage spool in position. For letter references see text.

METHOD OF TOWING

Not only am I indebted to the officers of the Department of Mine Design, H.M.S. 'Vernon', Portsmouth, for invaluable assistance in the design of planes and the balance of the machine, but also for kindly carrying out the trials to determine the depth at which the recorder swims for different lengths of rope used and the pull exerted on the rope.

The machine has been tested for stability up to a speed of 16 knots. The pull on the towing rope at this speed was found to be approximately 10 cwt. The thinner the towing rope the less is its resistance to the water and consequently the greater the diving performance of the machine (see p. 463). Yet a good margin of safety must be maintained, for the machines are costly.

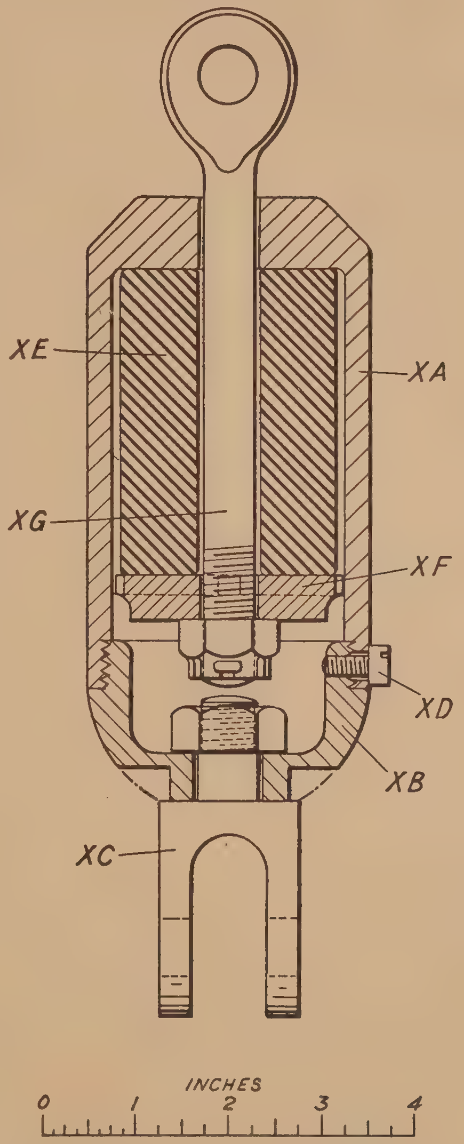

Fig. 17. Longitudinal section of the shock absorber or vibration damper placed between the towing eye and rope. For letter references see text.

I will describe the equipment employed in towing the recorders from commercial steamships across the North Sea. Whilst the ships co-operating do not attain speeds of more than 14 knots, and usually run at 11 or 12 knots, it must be expected that the pull on the rope in rough seas may at times exceed the calculated 10 cwt. for 16 knots. A breaking strain of 3 tons was decided on; but by selecting an aircraft cord which is made of a much higher tensile steel than ordinary commercial rope, it was possible to keep down its size to a diameter of 0·255 in. An unforeseen failure occurred. On a third run across the North Sea the rope broke and a machine was lost. The broken end was examined in the laboratories of Messrs British Ropes, Ltd., who were able to determine that the fracture was due not to overloading but to the development of fatigue through vibration. To overcome this difficulty three measures have been taken:

(1) Messrs British Ropes have made a special rope for this work which is the same aircraft cord as before but with the addition of a fibre core which has the effect of damping down vibration and so reducing the development of fatigue. The detailed specification of this rope is as follows: Drawn galvanized plough steel wire rope, 6/19 construction with a main fibre core, each wire 0·018 in. diameter; breaking stress 60 cwt.

(2) A special shock absorber in the form of a rubber compression block within a steel cylinder, illustrated in Fig. 17 and described below, was made to be fixed between the end of the rope and the machine. This has a further effect of damping down the vibration in the rope at the outboard end where it is likely to be greatest and where fatigue had previously developed.

(3) Between the towing rope and the shock absorber is shackled a double bridle (2 ft. 6 in. long) of the same specification as the towing rope. This gives double strength

at the point on the rope where fatigue is likely to develop. In the North Sea survey these double bridles are replaced by new ones after every crossing.[1] Their cost, eight shillings, is a small premium to pay for safety when the machine costs close on a hundred pounds. After three runs the outboard end of the main rope is shortened by a fathom, so that a possibly fatigued end is discarded; after a further three runs the rope is turned end for end, so that the inboard end not hitherto subjected to fatigue may now be used; after the next three runs the rope is again shortened by a fathom, and finally, on completion of twelve runs the rope is discarded.

Since these precautions have been adopted recorders have run for over 30,000 miles without further loss due to fatigue.

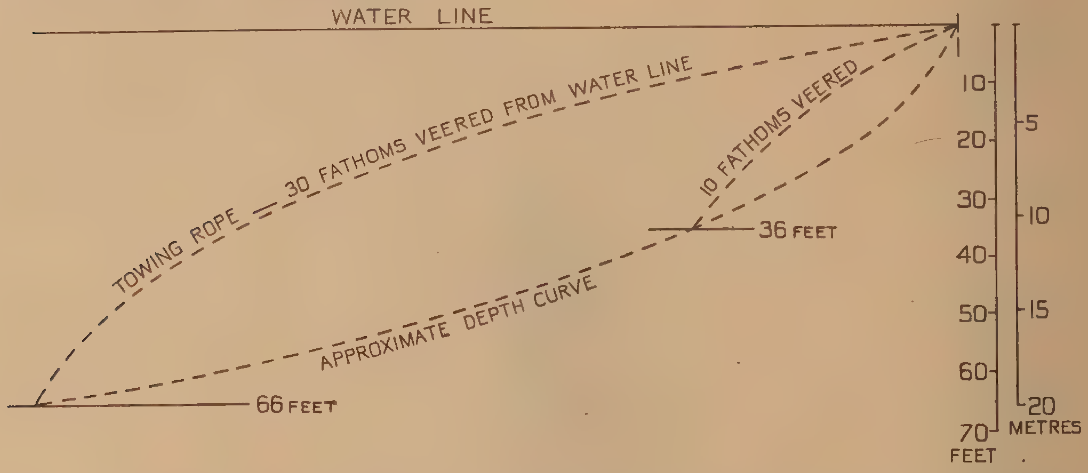

Fig. 18. Graph kindly prepared by the School of Mine Design, H.M.S. 'Vernon', Portsmouth, showing the depths taken up by the Type II Recorder with different lengths of towing rope of 0·255 in. diameter at speeds of eight to sixteen knots.

The shock absorber or vibration damper may now be described in detail. It is shown in position in Figs. 3 and 4, *X* and in section in Fig. 17. It consists of a steel barrel *XA* closed at one end and fitted with a screw cap *XB* at the other. The jaw *XC*, which is secured to the towing eye of the machine, has a pin formed on it which passes through the end of the cap and is secured internally by a nut which is tightened up to a shoulder on the pin; the end of the thread is riveted on to the nut. The end-cap is screwed into the main barrel and prevented from turning by a locking screw *XD*. Inside the main barrel is housed a cylindrical rubber compression buffer *XE* against the end of which a plate *XF* bears; the towing bolt *XG*, formed into an eye at its otuer end, passes through a hole in the closed end of the barrel, through the centre of the rubber buffer and through a hole in the plate *XF* against which it is secured by a castellated nut and split pin. The towing strain thus compresses the rubber between the plate and the closed end of the barrel; adequate clearance is allowed between the buffer and the barrel and the buffer and the bolt for the lateral spread of the rubber when under compression.

From trials carried out at speeds of 8–16 knots H.M.S. 'Vernon' has kindly provided the diagram given in Fig. 18 from which may be estimated the depth at which the recorder will run for different lengths of towing cable, 0·255 in. diameter up to 30 fathoms veered from the water-line. The depths were given in feet, but a scale of metres is now introduced at the side.

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[1] Except on the short Hull-Rotterdam line when they are replaced after every two runs.

In the beginning a ball-bearing swivel was used between the machine and the towing rope; but on the advice of H.M.S. 'Vernon' this was discarded as unnecessary and liable to unlay the wire rope.

METHOD OF WORKING UP MATERIAL COLLECTED

At the end of a run the storage spool is taken out of the preservation tank of the machine and may be kept in formalin until required for analysis. Examination of the roll is carried out by unwinding it on a stage beneath a traversing microscope; both have been specially designed for the purpose and are shown in Plate IV. Fig. 19 shows the examination stage in diagrammatic section. The storage spool is mounted at *A*, and the two gauze bandings are led off round the rollers *B*, *B′*, passed up and separated to the right and left over the glass stages *C* and *D*. The gauze passing over the stage *C* goes to the empty spool *E* and that passing over *D* goes round a series of rollers to pass back under the whole frame to the spool at *F*. *E* and *F* are geared to the handle at *G*; when this is turned the two bandings are drawn apart so that when a section of the graduated roll covers one stage the corresponding area of the plain gauze covers the other. The plankton is now exposed on the upper surfaces of the two gauzes as they lie

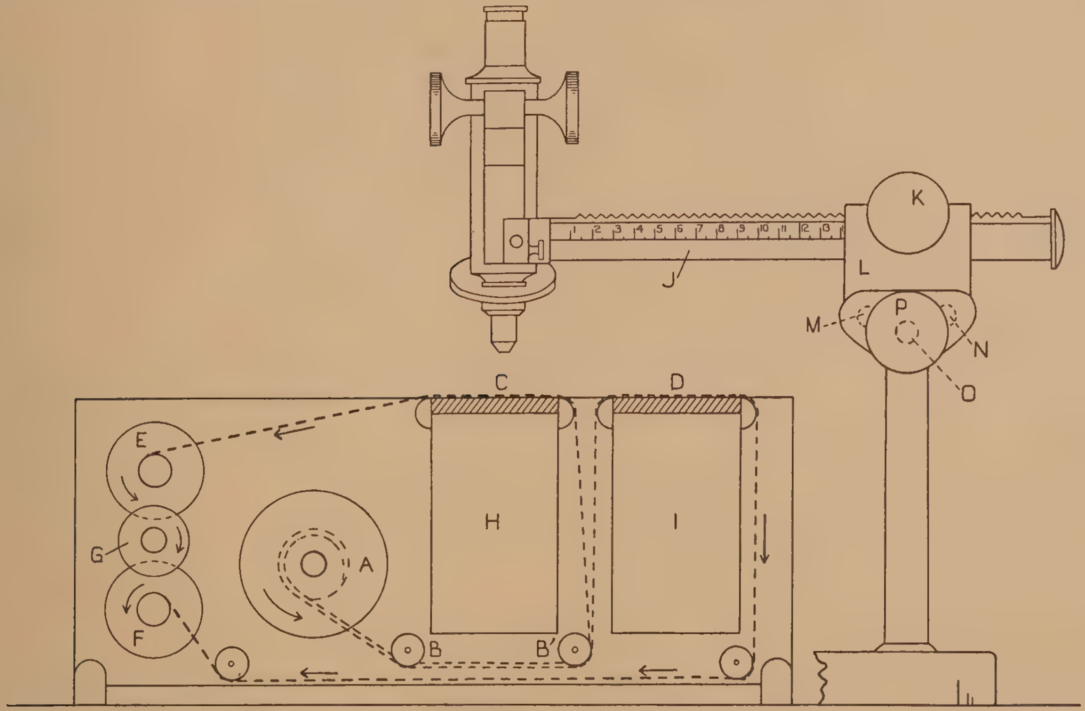

Fig. 19. Diagram of the stage designed for examining the recorder rolls under a traversing microscope (see also Plate IV). For explanation see text.

over the glass stages. Mirrors at *H* and *I* reflect light up through the glass stages, so that the plankton on the gauze may be examined *in situ* by the microscope. Each banding is examined; for whilst in the first place the plankton is caught only on the graduated gauze, some of it is transferred to the surface of the covering banding. The glass stages are ruled into squares by intersecting lines to facilitate counting; when using low-power lenses the squares on the glass show through the gauze above them.

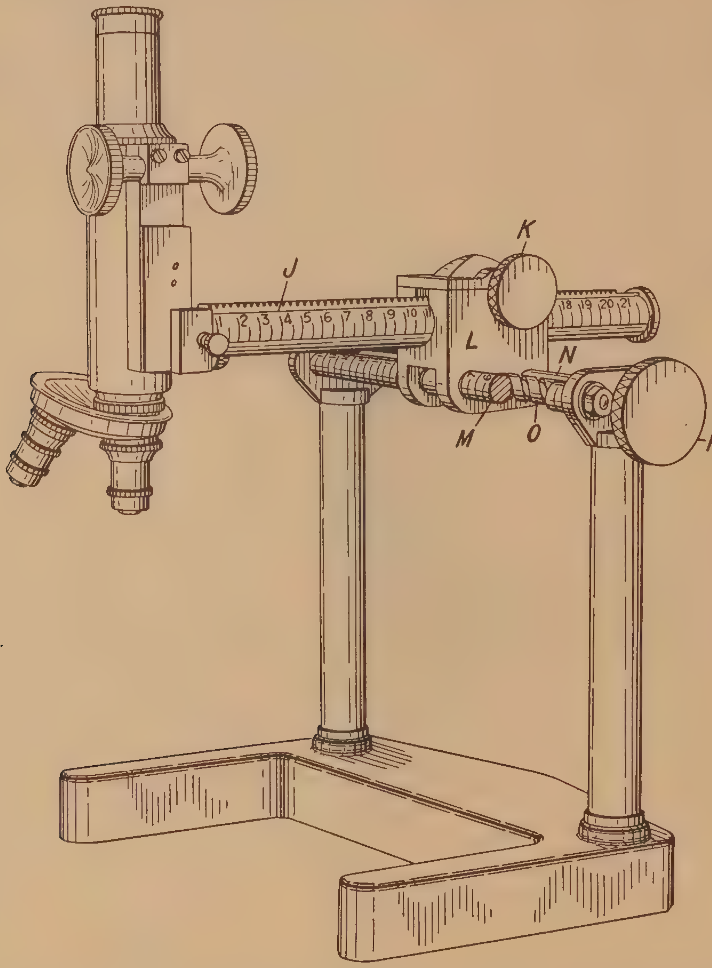

Fig. 20. Drawing of the travelling microscope designed for use with the examination stage. The graduated rod *M* is cut short to show the worm thread *O*. For further letter references see text.

Fig. 20 shows the traversing microscope in detail. A standard microscope tube is mounted on the arm *J* which may be moved from left to right by a rack and pinion turned by the milled wheel *K*. The carriage *L* which holds the arm *J* is mounted to slide along the two rods *M* and *N* at right angles to *J* and is moved backwards and forwards by a worm thread *O* turned by the milled wheel *P*. Thus by turning *K* and *P* the microscope may be made to cover any point of the examination stages *C* and *D* The arm *J* and one of the rods *M* are marked with a series of numbered divisions so that the position of the microscope objective over the stages may be noted at any time and then later returned to the same spot if required. The compound microscope body may be removed and replaced by a simple lens-holder for viewing larger objects if desired.

The larger and rarer organisms may be counted over the whole section and its counterpart of plain gauze. Smaller and more numerous organisms may be counted over selected areas and an estimate made of the approximate number on the whole section and its counterpart (see the next section on the interpretation of results). 1-in. and $\frac{2}{3}$-in. objectives are used for the examination of the majority of the zooplankton and larger phytoplankton forms ($\frac{2}{3}$-in. objective only), a $\frac{1}{6}$-in. objective being used for the smaller forms. If only parts are selected for examination they should consist either of a complete traverse across the section from side to side (at right angles to the line of motion of the gauze across the water tunnel in the machine) or areas covering representative parts of such a traverse. This is important because, owing to the slightly asymmetrical path of the water tunnel through the machine, the plankton tends to get thrown in larger numbers towards one side of the gauze than the other (see possible future modification of machine, p. 501).

It may not always be possible in the time available to carry out a complete analysis, so that only the forms considered to be of importance in a particular investigation can be identified and counted. After examination on the stage, however, it is advisable that the plankton should be removed and stored in tubes numbered to correspond with the respective sections, so that it may be later referred to should it be desired to carry the analysis further in the light of subsequent events. The larger forms may be picked off by forceps or sable brush and the remainder taken off with a safety-razor blade mounted in a handle. The needs of each particular piece of work will dictate the degree to which analysis is carried. For some classes of work it may be desirable to make a full quantitative analysis of every second, third or fifth section, and only a cursory examination of the intervening ones to see that no important variation in the plankton density has been missed.

THE INTERPRETATION AND CHARTING OF RESULTS

The process of analysis results in a record of the varying numbers of the different organisms caught in each of the consecutive sections of the gauze. The distance of the sea traversed for every section of gauze exposed is obtained by dividing the total distance of the run (known from the reading of ship's automatic log) by the number of sections exposed. If 50 sections have been exposed in a run of a 100 miles, for most practical purposes each section may be said to correspond to a distance of 2 miles of sea; actually, as will be shown presently, this is not strictly true, for each section will also sample a little of the water immediately preceding and following its corresponding 2 miles. But as a rule this effect may be disregarded (see below).

If one is merely making a study of the irregularity of distribution in different areas

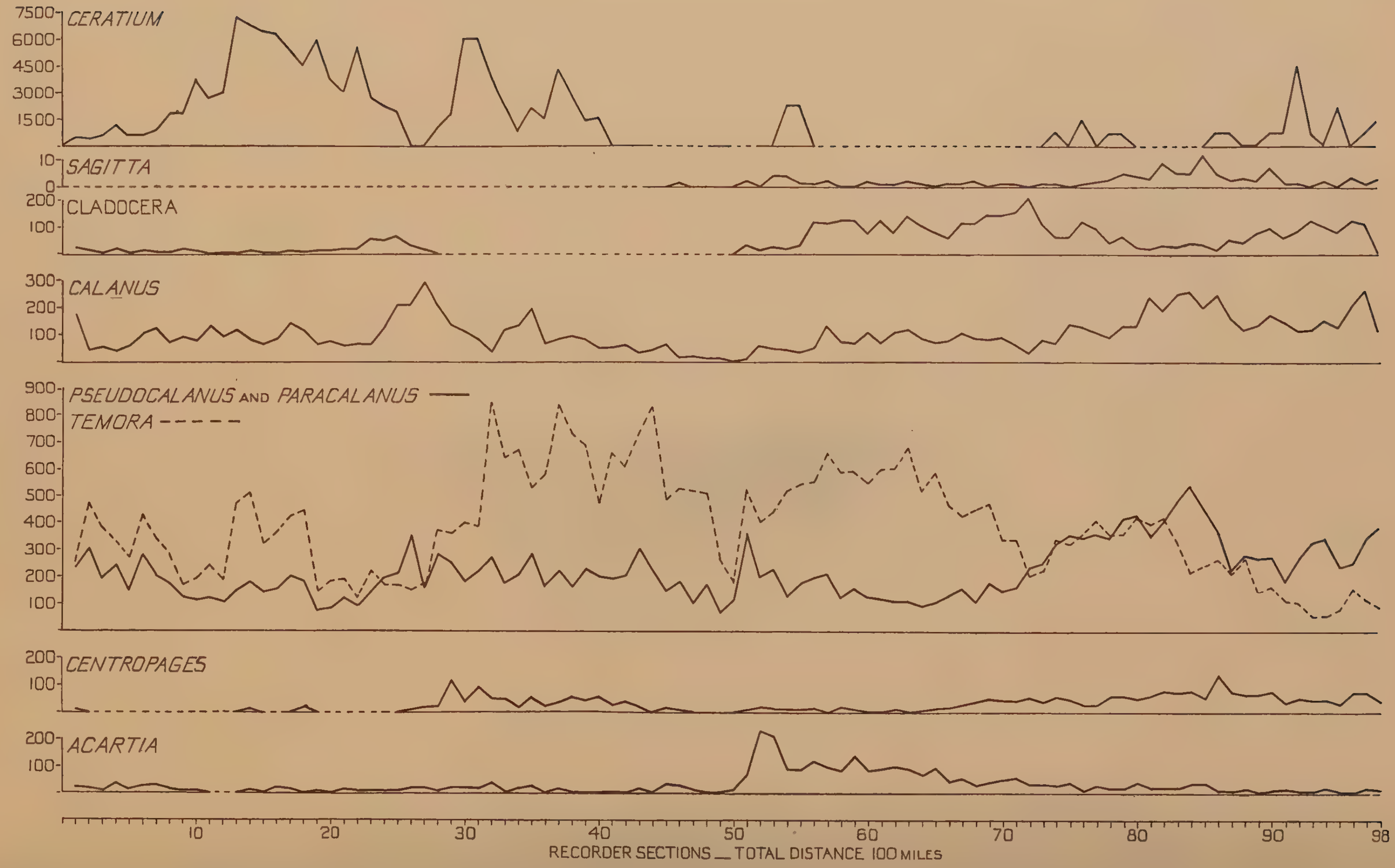

Fig. 21. Typical specimen graph showing an analysis of a Type II Recorder roll obtained in the North Sea between 57° 4′ N, 2° 0′ E and 55° 50′ N, 0° 5′ W on June 22, 1931.

the results may be charted directly in the form of numbers per section, with an accompanying distance scale below, as has been done in the preliminary study of the unevenness of oceanic plankton (Hardy, 1936). If the machines are being used for a periodic survey of an area, such as is being done in the North Sea, it is desirable to employ more refined methods of charting. The quantities of plankton recorded, both on different lines taken simultaneously and upon the same line at different intervals of time, should be strictly comparable. They may be made comparable by converting the number of organisms taken per section to the number taken per mile tow and the results (numbers per mile per section) graphed accordingly.

Fig. 21 shows a graph of a typical record obtained by the Type II recorder in the North Sea. The analysis was made by my colleagues, Dr G. T. D. Henderson and Mr J. H. Fraser.

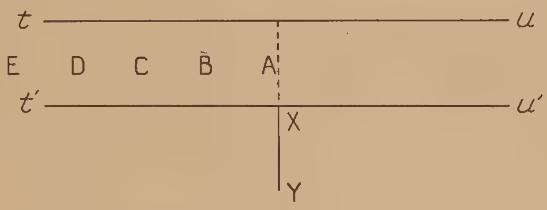

Fig. 22.

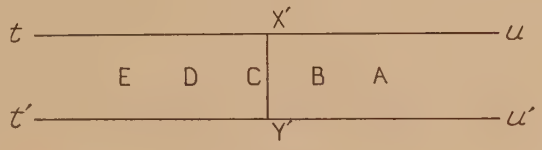

Fig. 23.

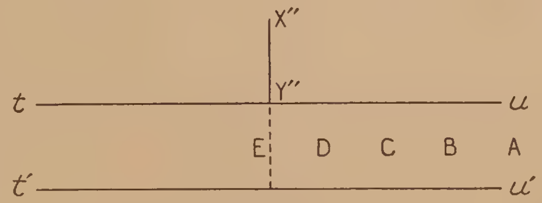

Fig. 24.

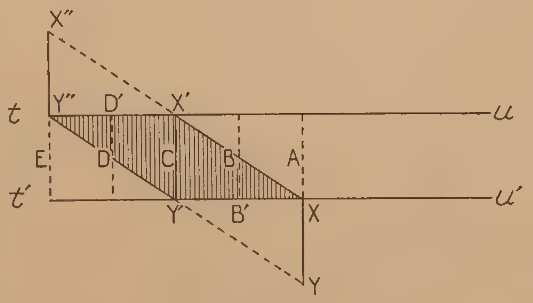

Fig. 25.

We have above indicated that a statement that each section of the gauze represents say 1, 1·5 to 2 miles of sea traversed can never be strictly correct. Each section of the graduated gauze covers exactly the area of the cross-section of the water tunnel at its point of traverse. Let us suppose that the gauze banding is being wound on at such a rate that any point upon it crosses the water tunnel in the same time as the machine has travelled 1 mile through the sea. In Figs. 22–25 let the horizontal lines tu and $t'u'$ represent the roof and floor of the water tunnel or their continuations, and let A, B, C, D and E be points in the sea half a mile apart along the path of the water tunnel which is being towed forward. Let XY be a section of the moving gauze banding which takes a path across the water tunnel represented by its dotted continuation. In Fig. 22 let X begin to cross the tunnel just as the point A in the sea crosses the path of the gauze. Now let X be wound across the water tunnel in the same time that the machine is towed through a mile of sea, so that in Fig. 23 X will have reached the position X' when C is passing through the gauze; Y will now be at Y'. In Fig. 24 the section XY has wound completely through the tunnel to X'' Y'', and E will be passing through the gauze of the following section.

In Fig. 25 let us combine Figs. 22–24. The sea *ABCDE* is really stationary, the tunnel moving from right to left, and *XY* in relation to the sea follows the path through *X′Y′* to *X″Y″*. *A*, *B*, *C*, *D* and *E* are at half-mile intervals. The water sieved by the section *XY* as it crosses the tunnel will be taken from the consecutive half-miles of sea in proportions corresponding to the areas covered by the parallelogram *Y″X′Y′X*. The triangle *BB′X* is one-eighth or 12½ per cent of the area of the parallelogram; so is the triangle *Y″D′D*. Thus of the water filtered by the section *XY* 75 per cent will come from the mile of sea *BD* and 12½ per cent from the preceding half-mile *AB* and 12½ per cent from the following half-mile *DE*.

Fig. 26 shows diagrammatically this relation of the sections on the gauze to the units of distance travelled if a point on the gauze crosses the water tunnel for every unit of distance that passes the machine. If the units of distance are miles, the proportions of the water filtered from each mile may be represented by the parallelograms *a*, *b*, *c*, *d*, *e*, *f*, ..., which lie across the rectangles 1, 2, 3, 4, 5, ..., which in turn represent the sections on the gauze. As seen in Fig. 25, 75 per cent of the water filtered by section 1 comes from mile *b* and 12½ per cent from the second half of the mile *a* and 12½ per cent from the first half of the mile *c*. Now if we examine only the plankton deposited along the dotted lines crossing the middle of the sections 2 and 3 at *x* and *z*, that on each line will be a sample representative of the miles *c* and *d* unadulterated by proportions of the plankton from the miles *b* and *d*, and *c* and *e* respectively. If the organisms we are estimating are small and numerous a single-line examination traverse may suffice to give an estimate of the number per mile. If we examine an area on the section 2 lying between the dotted lines *w* and *y* which lie at the quarters of the section, then the plankton will have come from water of which 87·5 per cent belongs to the mile *c* and only 6·25 per cent to the last *quarter* of the preceding mile *b* and 6·25 per cent to the first *quarter* of the following mile *d*. Similarly if we examine one-quarter of the section, with the line *x* down its middle, the plankton will have come from water of which 93·75 per cent belongs to the mile *c* and *only* 3·125 per cent to the *last eighth* of the preceding mile *b* and 3·125 per cent to the *first eighth* of the following mile *d*. Usually the plankton sample deposited on each section is rich enough to render a traverse examination of a quarter of the section or less sufficient to form the basis for an estimate of the whole; thus we may say that, for all practical purposes, the plankton estimated on each section does represent the plankton belonging to the mile (or whatever distance it is) which is known to have passed the machine during the time that a point upon the gauze has crossed the tunnel, i.e. the distance found by dividing the length of the run by the number of divisions exposed. It will of course be realized that Fig. 26 shows a geometrical representation of the proportion of the water filtered by each section; it does not mean, for example, that in section 2 the top right-hand corner only will filter water

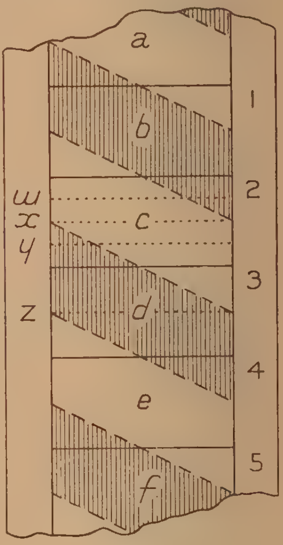

Fig. 26.

from mile *b*, but that the proportions of the water of *b* and of *c* filtered *along a whole line such as w* will be equal to the proportions of the line that cross respectively the areas *b* and *c* shown in the figure.

THE CATCHING POWER OF THE MACHINE

The full opening at the front, 1¼ in. square, could only be used with a much wider mesh gauze than the 60 threads to the inch at present employed as the standard mesh. The water tunnel enlarges to a cross-section of 8 sq. in. at the region of the gauze so that with a front opening of 1 in. sq. the speed of the water at the gauze is reduced to one-eighth of its speed at entry; thus at speeds of 12 knots it will be reduced to 1½ knots and at 8 knots to 1 knot. With the ¾ in. sq. opening, used as a standard in the North Sea survey, the speed of the water will be reduced at the gauze to one-fourteenth, so that at 12 knots it is reduced to less than 1 knot.

Assuming that all the water entering the tunnel flows through the gauze, then for every mile towed the following quantities of water would be filtered for the three openings:

1¼ in. sq.: 66 cu. ft. or 1·87 cu. m.
1 in. sq.: 42·2 cu. ft. or 1·19 cu. m.
¾ in. sq.: 23·75 cu. ft. or 0·67 cu. m.

Actually the quantity filtered is unlikely to reach the theoretical maximum if the larger openings are used with the 60-mesh silk.

An idea of the catching power of the machine may be gained from the following table which expresses the numbers taken per 1 mile tow of a selected number of organisms when the ¾ in. sq. opening has been used. The figures are maximum numbers taken from the survey at present in progress in the southern North Sea:

Diatoms	*Rhizosolenia styliformis*	60,000
	Biddulphia sinensis	54,000
Dinoflagellates	*Ceratium*	200,000
Chaetognatha	*Sagitta*	457
Cladocera	*Podon*	503
	Evadne	1633
Copepoda	*Calanus finmarchicus*	168[1]
	Pseudocalanus elongatus	1450
	Temora longicornis	1040
	Centropages	390
	Acartia	500
Amphipoda	*Proto pedata*	47
Pteropoda	*Limacina*	980
Echinoderm larvae		3240
Fish eggs		7
Post-larval fish		20

The above figures illustrate its capacity; a typical fluctuation in numbers is shown in the specimen graph in Fig. 21. It is a feature of the method that smaller samples are collected than by the use of the ordinary tow-net, but large enough ones to show the important differences in the abundance of the plankton. More often than not the tow-net yields samples, the contents of which can only be estimated in the laboratory by counting a very small fraction, possibly $\frac{1}{50}$ or $\frac{1}{100}$, and making an estimate. The tow-net sample to begin with is taken from a confined area of sea, perhaps not more than a quarter of a mile tow when using a fine or medium silk. Thus by the tow-net method there are two large sources of error in estimating the quantity of plankton in the area examined. The sample itself may not truly represent the area as a whole owing to the patchiness of the plankton; then after having taken so large a sample there is the laboratory error in taking the fraction for examination. In the stempel pipette method, or other means of fractioning, all organisms may not be taken up in their true proportions. The recorder method takes a smaller sample over a wide traverse of sea, eliminating to a large extent both the factors of patchiness in the sea and the fractioning in the laboratory. When a fraction only of the section can be examined, that fraction is not such a small one as is usual in tow-net sample analysis, and the sample is deposited on the gauze by the sea itself so that the organisms are presented for estimation in exactly their true proportions. The gauze section represents the "telescoping" of the plankton in a long volume of sea into a small two-dimensional space for the convenience of examination. If each section is regarded as a sample we may say that the recorder method presents us with a large number of small but representative samples spread over the whole line of the traverse instead of a few large tow-net samples taken at intervals.

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[1] The numbers of *Calanus* in the southern North Sea are very low compared with more northern waters.

LIMITATIONS OF THE METHOD

As in all methods there are limitations, and before making use of the instrument for any particular investigation they must be carefully weighed against the possible advantages. There appear to be two major limitations. Firstly, in regions of rich plankton the small filtration area of silk is apt to become somewhat clogged so that filtration and catching power are reduced. This difficulty applies, although to a lesser extent, to ordinary tow-nets. It is perhaps not so serious a limitation as it may at first sight appear; it means that whenever organisms are taken in very large numbers one must realize that the actual numbers present in the sea are very much larger. The peaks on the graphs made from the records should be higher than they actually appear. A study of the published examples of such graphs (Hardy, 1935, 1936) will show what great differences in numbers may be recorded; clogging in fact does not conceal these differences; there is no evidence of the numbers reaching a limit to produce a more or less uniform maximum deposit of plankton. It must be remembered too that continually there is a fresh surface of gauze being presented to the water flow as the thick deposits of plankton pass on into storage.

The second and more serious limitation is that due to the use of only one instrument, making a record at a uniform depth when some organisms are carrying out diurnal vertical migrations. The influence of vertical migrations on the records is clearly shown in some of the graphs obtained in deep-water areas (Hardy, 1936), but does not appear to have a pronounced effect in the survey over the shallower regions of the North Sea where the machines are run at a uniform depth of 10 m. (see Hardy, 1935, fig. 10). An ideal arrangement would be the towing of two or more machines one below the other at convenient depths apart, or the introduction of a device which, by moving the diving planes by a cam action from the driving mechanism, would make the machine take a regular undulating path through the sea. This latter very interesting suggestion was made to me by Mr J. O. Borley, O.B.E., and is discussed in the later section on possible developments in machine design; it appears to be a perfectly feasible adaptation which should remove what appears to be the most serious limitation to the method.

Another disadvantage of the method lies in the damage that may be done to specimens in the process of winding when they may often be crushed and broken, rendering identification a longer and more tiring process than the examination of ordinary tow-net samples. For this reason the instrument is not suitable for general survey work in an area where the plankton is not well known; a good knowledge of the commoner forms should first be obtained by the use of ordinary tow-net methods. It is hoped that this difficulty too will largely be overcome by improvements in the mechanism (see p. 500). It should be noted that the plankton is not crushed between the driving rollers which do not press together except at their ends, where they tightly grip only the edges of the gauze outside the plankton zone.

SOME CAUSES OF MECHANICAL FAILURE

At times from one cause or another the mechanism fails, causing a stoppage of the record. It may be convenient to refer briefly to four possible causes of failure, so that other workers using the machine may know what to look out for.

(1) The brakes on the supply spools may have been adjusted too tightly, so that they jam and the gauze fails to wind off.

(2) Pieces of grit may get caught in between either roller *l* or roller *o* and part of the frame (see Fig. 10), so that they no longer turn; this may prevent the gauze from passing on.

(3) The friction drive may become too slack so that it slips the whole time, with the result that the gauze bandings which have passed through the driving rollers are not taken up by the storage spool but curl over the driving rollers until eventually they may get caught round the forward driving roller and be wound upon it till the mechanism jams.

(4) Another stoppage is one which will only develop in an old machine and is due to the wearing of the rubber ends of the forward driving roller against which the toothed metal ends of the rear driving roller press. It becomes reduced in diameter, so that the other roller no longer exerts sufficient pressure to drive on the gauze; the blunt teeth just slip on the gauze which remains stationary. Any sign of wear should be carefully looked for and as soon as it becomes evident the ends of the rollers should be replaced by new ones.

The present degree of efficiency of the mechanism may be judged from the following figures relating to the North Sea recorder survey. During the year ending 30 November 1935 forty-seven recorder runs were made across the North Sea only two of which were failures due to mechanical breakdown, thus showing a 95·7 per cent efficiency. The total sea mileage recorded successfully during the period was 7827. The previous year was not so good: out of fifty-three runs nine did not record the full distance through mechanical failure, giving an efficiency of only 83 per cent; but in the year before it was again higher, giving 91·8 per cent efficiency.

The successful running of the machine is dependent upon careful preparation in loading (p. 470) and thorough cleaning and inspection after each record.

POSSIBLE FUTURE DEVELOPMENTS IN THE MACHINE DESIGN

From time to time small improvements are made in the design, and later publications will record alterations which are found desirable. It may not be out of place to refer briefly to some of the possible more important developments in design that can be foreseen.

First place must be given to Mr J. O. Borley's valuable suggestion, already briefly referred to (p. 499), for getting over the difficulty of successfully recording vertically migrating organisms by moving the diving planes so as to make the machine take an undulating path through the water. An extension of the worm shaft *VE* (Figs. 4, 10) through the body of the machine would provide the necessary drive to operate a movement of the planes. The planes could be moved very slowly by a cam action, so that the machine would make a complete oscillation in depth between say 50 and 5 m. (the range to be adjusted according to the depth of the area investigated) for every mile of tow, so that each section examined would cover twice the whole range of depth and be the equivalent of a double oblique haul. Such an oscillation of 50-m. depth (or less) in a distance of a mile would mean only a very gradual climb and fall of the machine, so that no undue strain should be anticipated. At first sight a regular alteration in the tilt of the diving plane might seem to be the simplest method of achieving this result; but this would mean a continual movement of the centre of pressure in relation to the centre of gravity of the machine, and this might well be fatal to the maintenance of stability at high speeds. A better method would seem to be a regular alteration in the area of the diving plane without altering its angle of incidence; this could be done by arranging extensions on each side to slide in and out by a rack and pinion action driven from an extension of vertical shaft *VE* just referred to. Such an arrangement would give a periodic increase and decrease in the downward thrust without in any way disturbing the stability of the machine. Experiments are shortly to be made in this direction.

It is hoped in later machines to improve greatly the condition of the plankton collected by eliminating the tendency to crushing in the process of winding on the storage spool. This could be done by enlarging the formalin tank to make room for another spindle, on the ends of which would be mounted narrow reels holding rolls of strip rubber, which would wind on to the storage spool between the *edges* of the layers of gauze and so take off the pressure of winding from the centre section containing the plankton. Fig. 27 shows how this may be achieved, the rubber strips being shown in black. As already explained, the plankton is not subjected to any pressure in passing between the driving rollers (p. 469).

It would be a great advantage to be able to use two grades of gauze, one of coarse mesh for the zooplankton and one of much finer mesh for the phytoplankton. Attempts using a ribbon of fine-mesh gauze sewn on to the coarser gauze to entrap the smaller phytoplankton forms have not proved successful. It is hoped later to construct a miniature auxiliary water tunnel which could be fixed to the body of the standard machine, so that a narrow very fine-mesh gauze within it could be wound on at the same rate as the gauze in the main recorder; it would be worked by an extension from the main driving gears. Alternatively the main water tunnel could be divided by a vertical partition to separate a narrow tunnel leading to a fine-mesh gauze placed side by side with the coarser gauze, the two fabrics winding on together into the formalin tank. The front opening of the small tunnel could be reduced to a mere $\frac{1}{8}$ in. sq. to allow for the greatly reduced filtration with the fine-mesh gauze.

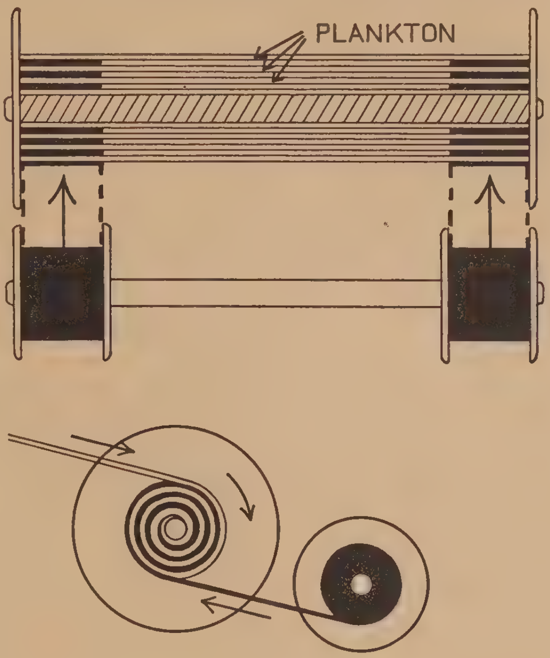

Fig. 27.

In the Type I machine with a larger opening a grid of intersecting wires was placed at the front opening to prevent large objects entering the water tunnel; in the Type II machine with the very much smaller opening the grid was dispensed with. Recently two records have been spoiled by pieces of fish, evidently struck off by the nose of the machine, entering the water tunnel and jamming against the slit for the exit of the gauze. It is proposed to reintroduce a protective grid at the front opening.

A series of vertical vanes might be fixed within the water tunnel to prevent the tendency of the plankton to be carried more to one side of the gauze than the other on account of the slightly asymmetrical path of the water tunnel (see p. 468).

My colleague, Mr C. E. Lucas, has suggested a modification of the machine so that it could be used in one place for recording changes in the plankton in a time dimension. Instead of the machine being towed through the water, a propeller fitted into the water tunnel behind the gauze and driven by an enclosed electric motor could be made to draw a current of water through the gauze, so that changes in the composition of the plankton at different levels could be measured throughout the day. The technical difficulties of enclosing a motor of sufficient power in a watertight chamber in any but shallow depths of water would be considerable, especially when the chamber would have to be pierced by the drive for both the propeller and the winding mechanism. But the possibility of such an adaptation should not be lost sight of.

ACKNOWLEDGEMENTS

There are many people to whom I am indebted for help in the development of the Continuous Plankton Recorder. First and foremost I wish to express my great sense of gratitude to Dr Kemp, who gave such sympathetic support to the initiation of the project, followed by never-failing encouragement during the often disappointing trials of the first machine, and to the Discovery Committee who so generously made possible the realization of the idea.

The working drawings of the original Type I machine were prepared from my sketches by Mr M. T. Denne, who made a number of valuable suggestions regarding the details of construction. The working drawings for the Type II machine were made by Messrs R. W. Munro, Ltd., of South Tottenham, London, who have built all the machines to date and to whom I am also indebted for suggestions as to methods of construction.

I have already recounted how the system of diving planes I had designed from experiments with models failed to give stability to the full-sized machine. The conversion of this failure to success I owe to the kindness of the Officer Commanding the Department of Mine Design, H.M.S. 'Vernon', Portsmouth, and his staff, who carried out stability tests, designed the present system of planes and weighting of the machine, and furnished me with the data regarding the depth to which it will descend for a given length of towing rope.

During the 1925–7 voyage of the 'Discovery' much of the successful performance of the first machine was due to the mechanical skill of my former colleague, Mr H. F. P. Herdman, who performed many an operation on its internal mechanism to improve its working. Similarly at Hull in the running of the Type II machine and its improved efficiency in the field we owe much to the mechanical knowledge of our present colleague, Dr G. T. D. Henderson.

The excellent drawings of the machine which illustrate the present report have been made by Messrs Garrett and Campbell, Ltd., 88 Chancery Lane, London, W.C. 2.

SUMMARY

The Continuous Plankton Recorder has two main functions: firstly, it enables one to study in detail the changes in the abundance of different plankton organisms along a continuous line of observation through the sea, and secondly, if several are used simultaneously they enable one to carry out broad periodic surveys using commercial ships. It renders possible the introduction of meteorological-like methods into the treatment of planktological problems concerning wide areas of sea. Other uses are discussed.

The instrument is provided with diving planes and, when towed like a paravane behind a ship at the required depth, continually samples the plankton in the water traversed. A propeller turned by the passing water causes a long banding of gauze to be wound across a flow of water through the machine, where it sieves out the plankton; immediately after leaving the water tunnel this gauze banding is joined by another so that the plankton is imprisoned between the two and prevented from moving; the two bandings are now wound onto a storage spool in a preservation chamber. The gauze is graduated into numbered divisions and each section may be made to represent one or more miles of sea traversed by adjusting the pitch of the propeller blades. The spools have a capacity for a 250-mile record; at the end of the run they may be changed like the spools of a roll-film camera and the used ones kept for examination on a special stage beneath a traversing microscope.

The evolution of the machine is briefly dealt with and the latest machine described in complete detail.

The method of towing, the process of analysis, the interpretation of results, the catching power of the machine, and the limitations to the method are dealt with (see contents table).

Possible future developments in machine design are discussed.

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APPENDIX

A test of the validity of the continuous plankton recorder method

By A. C. Hardy, M.A. *and* Nora Ennis, B.Sc.

In April 1929 with the kind permission of Dr E. S. Russell, Director of Fisheries Investigations, Ministry of Agriculture and Fisheries, one of the authors (A.C.H.) carried out trials with the modified Type I Continuous Plankton Recorder from the research ship 'George Bligh' during a cruise in the southern North Sea. The object was to test several modifications in the mechanism before embarking upon the construction of the first of the Type II machines.

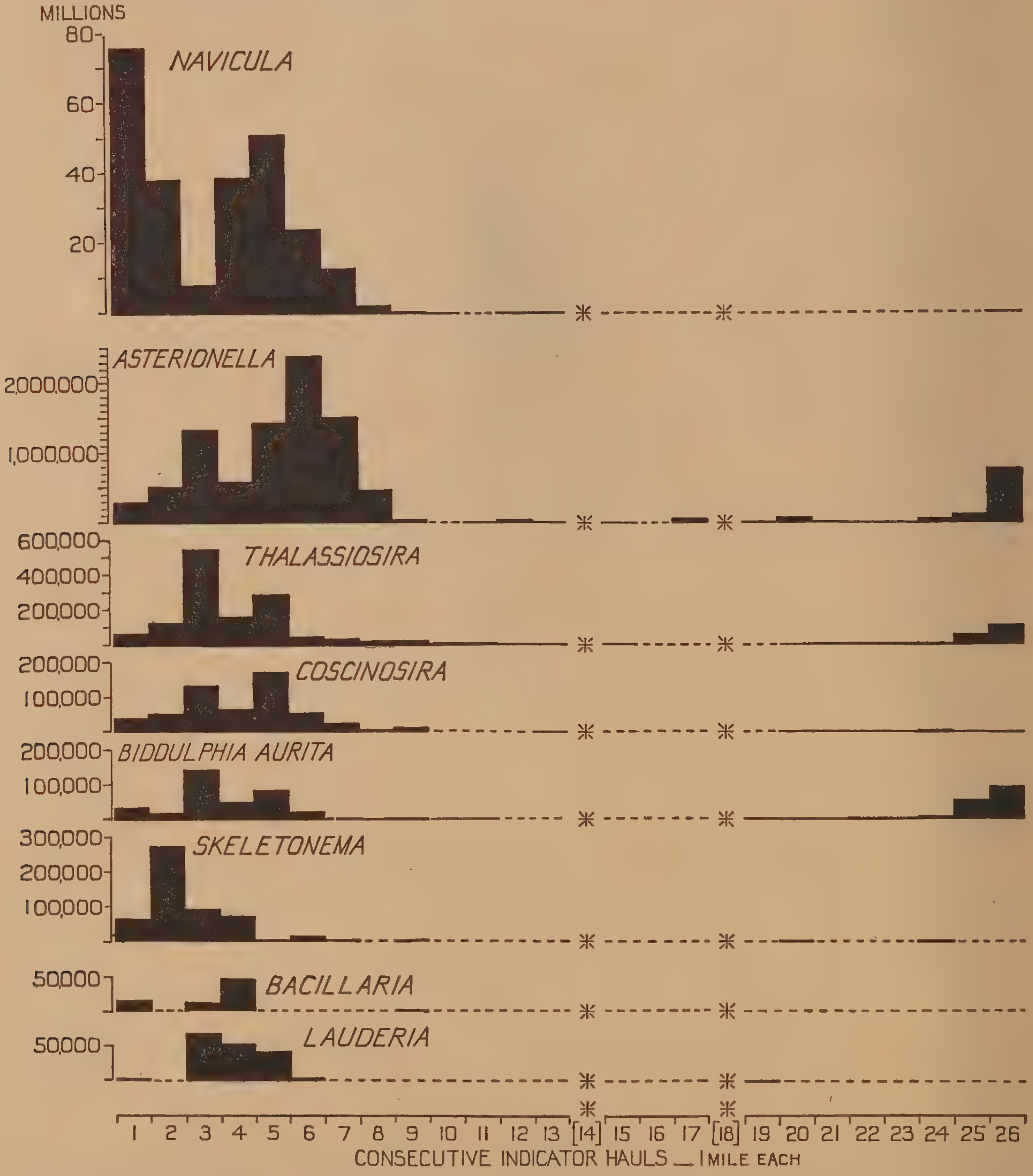

Fig. 28. Histograms showing the relative quantities of phytoplankton taken in consecutive samples obtained with the Plankton Indicator in the North Sea on April 8th, 1929. Samples 14 and 18, indicated by asterisks, were unfortunately lost before analysis. For further details see text.

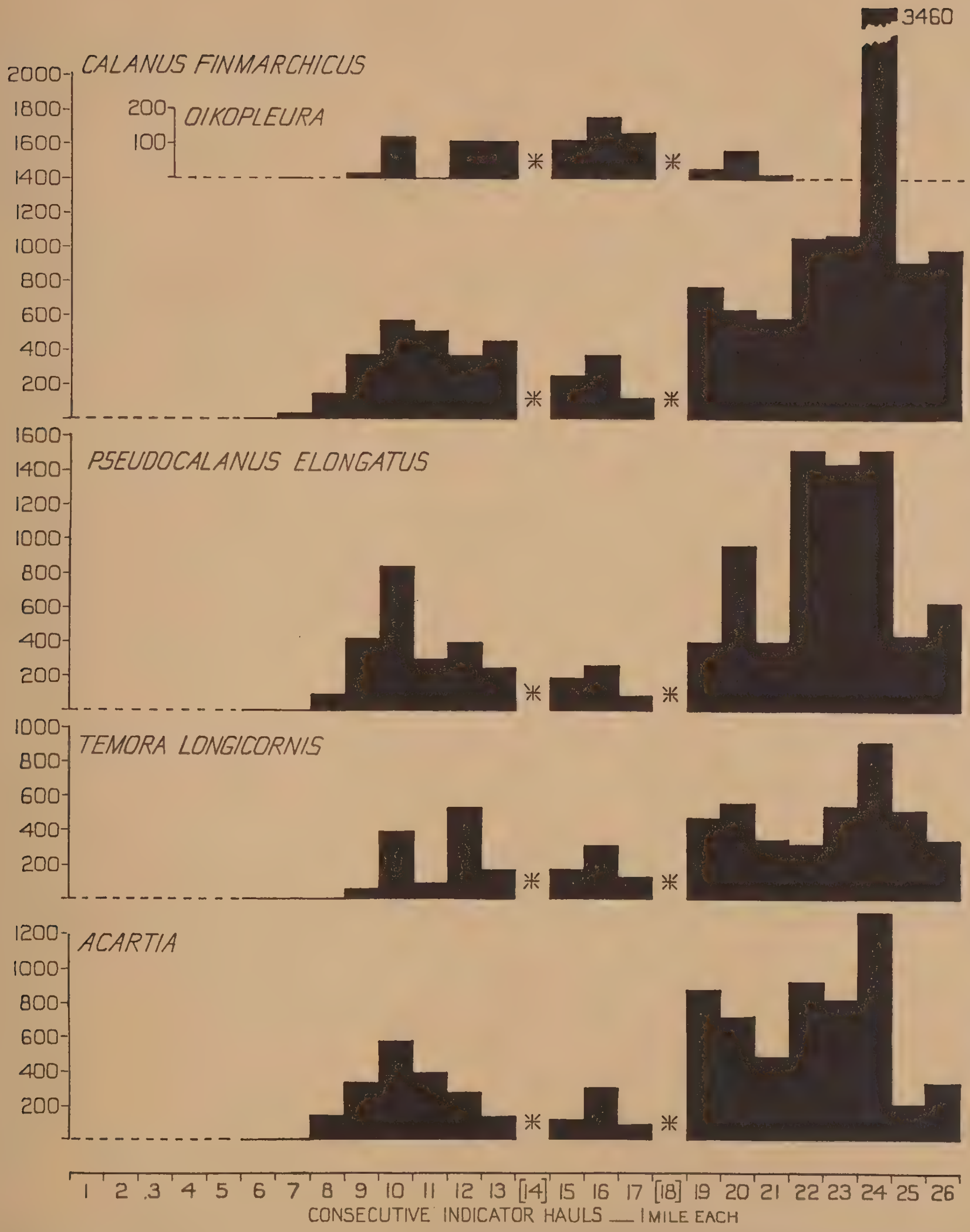

Fig. 29. Histograms showing the relative quantities of the more important zooplankton species taken in the same series of consecutive Indicator samples as those referred to in Fig. 28. Samples 14 and 18, indicated by asterisks, were unfortunately lost before analysis.

During this cruise a series of consecutive hauls was made with the Plankton Indicator, a small instrument which is fitted with planes and towed like the Recorder but has, in place of the moving bandings, a simple gauze disc for the collection of the plankton.[1] The discs are taken out and changed after each haul. It was towed at about three metres below the surface and after each haul of just under one mile by the ship's log, it was reloaded and immediately shot again. The process was repeated in exactly the same way until twenty-six consecutive hauls had been obtained. The analysis of the samples was made by the second author (N.E.). The primary object of the experiment was to show whether or not the types of fluctuation in the numbers of plankton organisms shown by the continuous Plankton Recorder really represented fluctuations in the sea and were not due to variations in the mechanical working of the machine; each separate indicator disc sample corresponding to a small section of a recorder roll.

The series of consecutive samples was taken on April 8th, 1929, on a straight line between 52° 37′ N, 3° 30′ W and 52° 28′ N, 4° 10′ W, beginning at 1822 o'clock and ending at 2304 o'clock. Of the twenty-six samples two unfortunately (numbers 14 and 18) were lost before analysis owing to tube breakage in the transit of material. The results of the analysis of the remainder are shown as histograms in Figs. 28–30. For the first eight miles the phytoplankton (Fig. 28) was abundant but varied greatly in quantity; it was then taken in negligible quantities until the last two miles when an increase of three species occurred. The zooplankton (Fig. 29) on the other hand was negligible for the first seven miles but present in varying quantities for the remainder of the line. Whilst there are differences in the spatial fluctuations of the four predominant species of Copepoda they all show on the whole a remarkable similarity in the main outline of their distribution; each shows a lesser zone of abundance about sample 10 and a larger one towards the end of the series. Such an occurrence, if found on the recorder roll, might give rise to doubts as to whether it might not be due to some variation in the working of the mechanism. Here each sample was taken independently in exactly the same way. Such a close correspondence in the fluctuations of several different species of Copepoda is, on the evidence of a large number of subsequent continuous records, a comparatively rare occurrence; it was fortunate that it occurred on the occasion of this test series of indicator samples so that its reality could be verified. The total phytoplankton and the total copepoda are charted together in Fig. 30; the possible significance of this distribution will be referred to later.

The reality of the marked variations in the abundance of the plankton from mile to mile in the sea need not be laboured. The results of this consecutive series of indicator samples, together with those taken with larger tow-nets at South Georgia in 1927 (Hardy and Gunther, 1935, p. 255) already referred to in the main paper and a similar consecutive series in the South Atlantic (Hardy, 1936) show that the marked variations in numbers typically revealed by the Continuous Recorder may be regarded as real variations occurring in the sea.

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[1] A description of this instrument is now in the press (Hardy, 1936, *Journal of the Marine Biological Association*); it is an improvement upon that previously described (Hardy, 1926, *Fishery Investigations* (England), Ser. II, Vol. VIII, No. 7).

Whilst the consecutive indicator samples were being taken the Continuous Plankton Recorder was also working. It was not however intended that the indicator series should

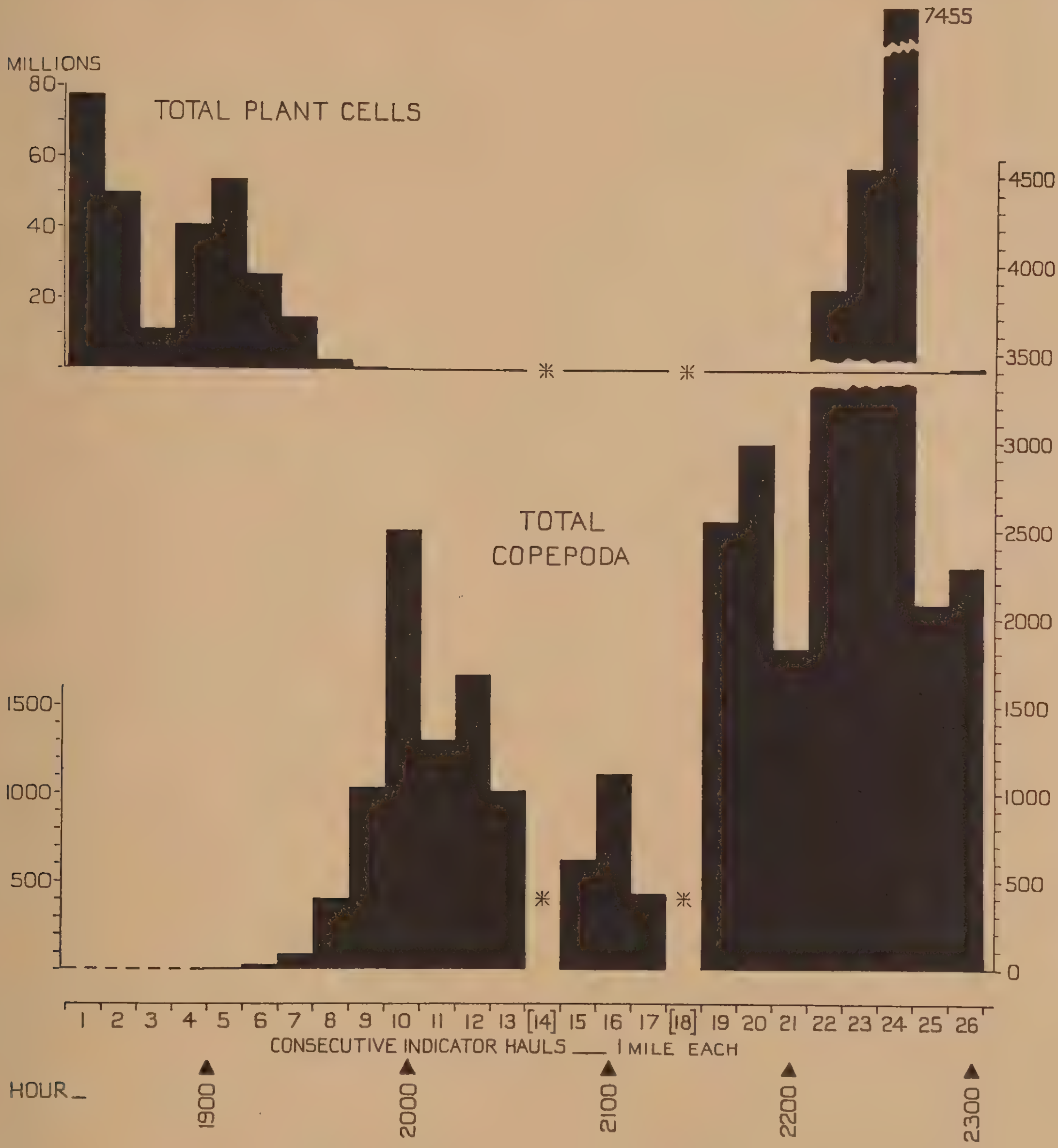

Fig. 30. Histograms showing the total phytoplankton and total Copepoda taken in the same series of consecutive Indicator samples referred to in Figs. 28 and 29. Samples 14 and 18, indicated by asterisks, were unfortunately lost before analysis.

give results to be compared exactly with those from the Recorder for the latter was being tested at a standard depth of 10 m. for the cruise whereas the indicator was not then designed to reach a depth of more than a few metres. Further, on this occasion the recorder propeller, an experimental one, was only winding on one section of the roll for every 3·5 miles of sea traversed and again the apertures of the two instruments varied,

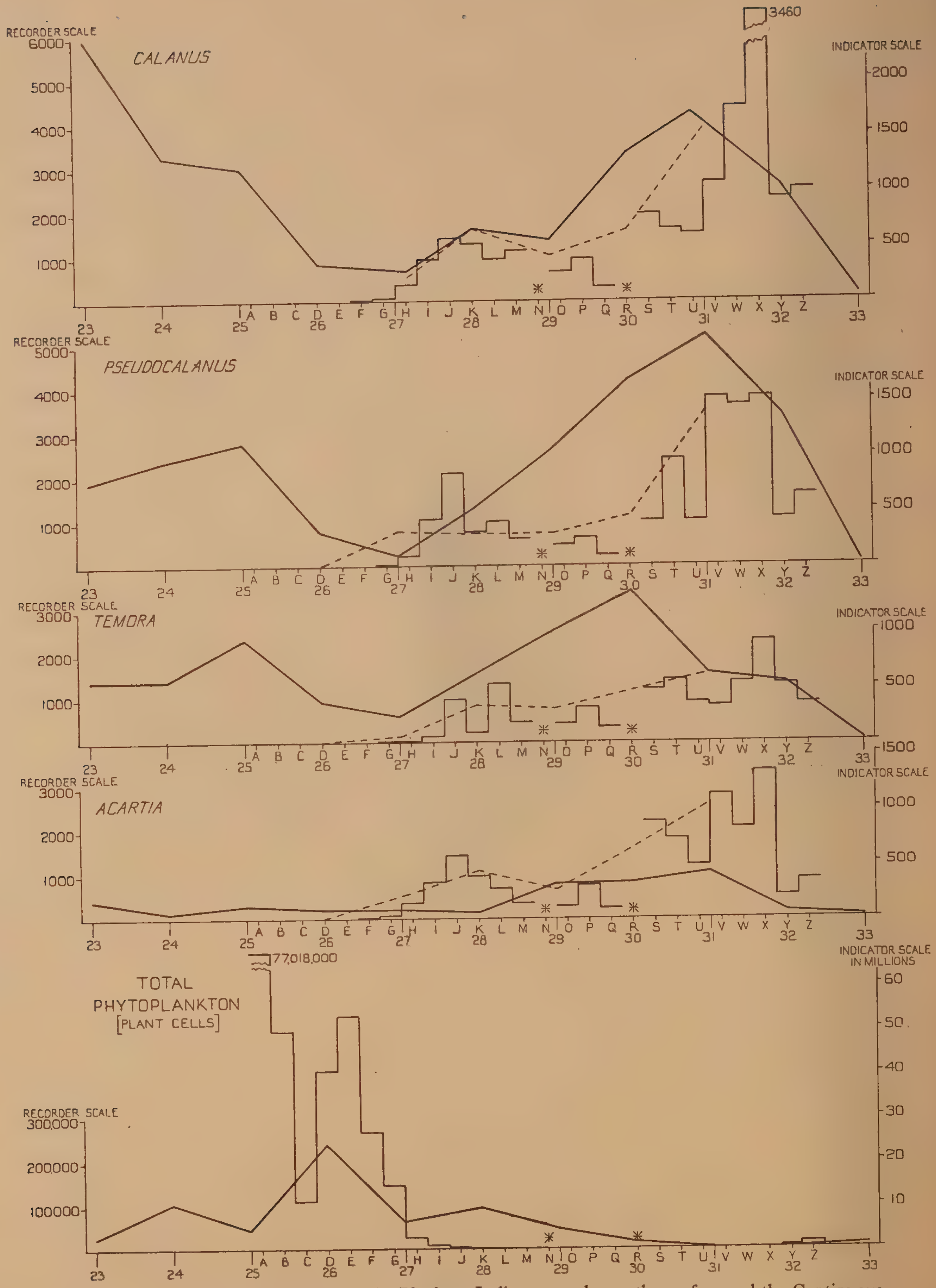

Fig. 31. Comparison of results from the Plankton Indicator used near the surface and the Continuous Recorder used at 10 m. depth. For full explanation see text.

the Recorder (Type I) being fitted with a 3 in. diameter opening as compared with the $1\frac{1}{2}$ in. opening of the Indicator. However, a comparison of the results is not without interest. The variations in the numbers of the four predominant species of Copepoda and the total phytoplankton obtained by the Recorder are shown in Fig. 31 as continuous line curves together with the indicator results as histograms in their relative positions along the line of traverse. The positions of the twenty-six indicator samples (each one mile tow) are shown by the letters *A* to *Z* to distinguish them from the positions of the recorder sections (each taken over 3·5 miles) numbered 23 to 33. The recorder run ended at section 33; the earlier part of the record before section 23 is not figured. Now it has been shown in the main part of the paper, p. 495, that a section of the recorder roll samples not only the plankton of the unit of distance (in this case 3·5 miles) travelled by the machine as a division winds across the water tunnel, but also a fraction of the preceding and following unit of distance. Calculations have been made on this basis to render the results from the Indicator as closely comparable as possible with those from the Recorder and the result is shown in the diagram as a broken line. This result is probably rendered less reliable on account of the loss of the samples 14 and 18 (*N* and *R*) which for purposes of the calculation were given values based on an average of the two adjacent samples, but which in reality may have varied markedly from them. In spite of the difference in the depth of the two instruments the general increase in the numbers of *Calanus*, *Pseudocalanus*, and *Temora* over the recorder sections 27 to 31 is well confirmed by the indicator samples, as also is the fall in numbers at the end of the record if the histograms are followed (the calculated broken line cannot be extended beyond section 31 because at section 32 the Recorder is sampling also fractions of the area which extends beyond the last of the indicator samples). The correspondence between the *Calanus* curves, in spite of the loss of the samples *N* and *R*, is particularly close. The *Acartia* result shows a marked difference probably due to the difference in depth distribution. The zone of phytoplankton abundance shown by the indicator samples corresponds with the peak of abundance in the recorder record, but here again difference in depth may likely account for the difference in general distribution. Near the surface the Indicator reveals a dense concentration of phytoplankton at samples 1 to 8 (*A* to *H*) and but little beyond; at 10 m. depth the Recorder shows much less but more widely spread.

A brief note may be added on the distribution of the phyto- and zooplankton. If considering indicator samples alone, it might be thought that the increase of zooplankton away from the phytoplankton zone might be explained simply as an increase caused by vertical migration bringing more of the animals into the path of the Indicator with the passage of time towards night. A time scale is shown in hours in Fig. 30. But now referring to the recorder graph we see that there were also larger numbers of the same species of Copepoda *before* the patch of phytoplankton was encountered, i.e. earlier in the afternoon. It would appear then that here is further evidence of the inverse distributional relationship between phyto- and zooplankton discussed in Part v of the report (Hardy and Gunther, 1935) already referred to in the main paper.

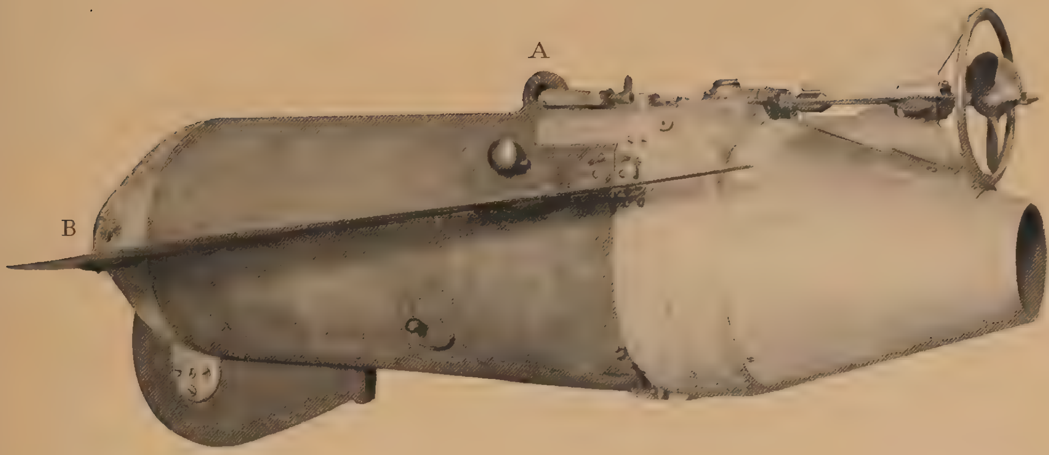

Fig. 1. The Type I Continuous Plankton Recorder, as first constructed, seen from the left-hand side. It was designed to be towed by a chain bridle (not shown) linked to the three eyes A, B, and one similar to B on right-hand side.

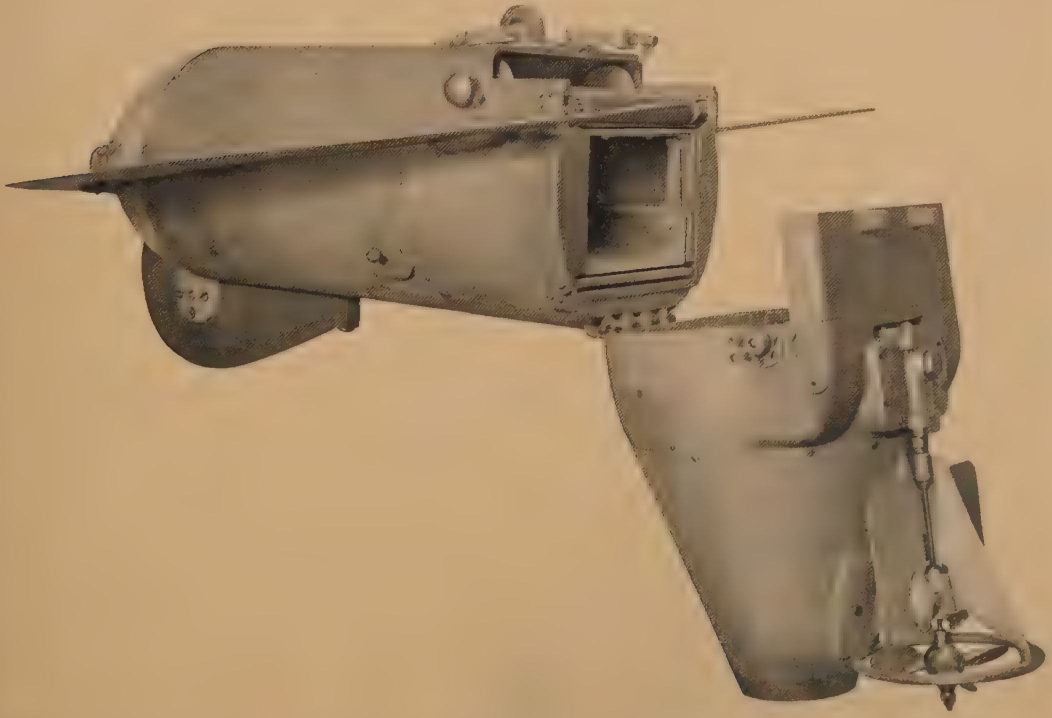

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Fig. 2. The Type I Continuous Plankton Recorder opened ready for loading gauze bandings.

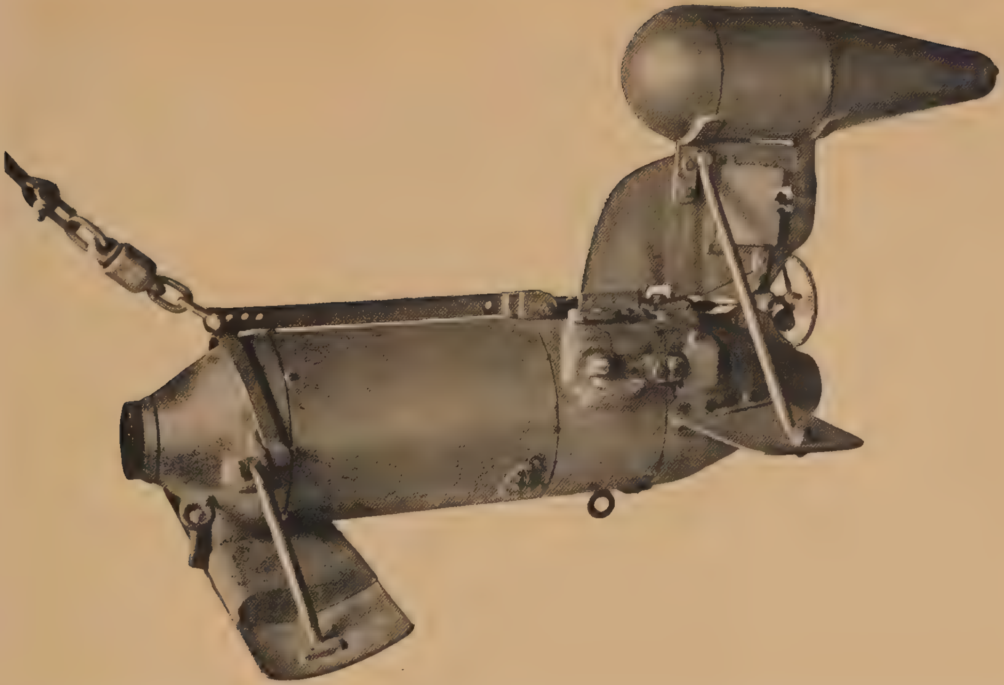

Fig. 1. The Continuous Plankton Recorder, Type I modified, as used on the R.R.S. Discovery's voyage, 1925-27.

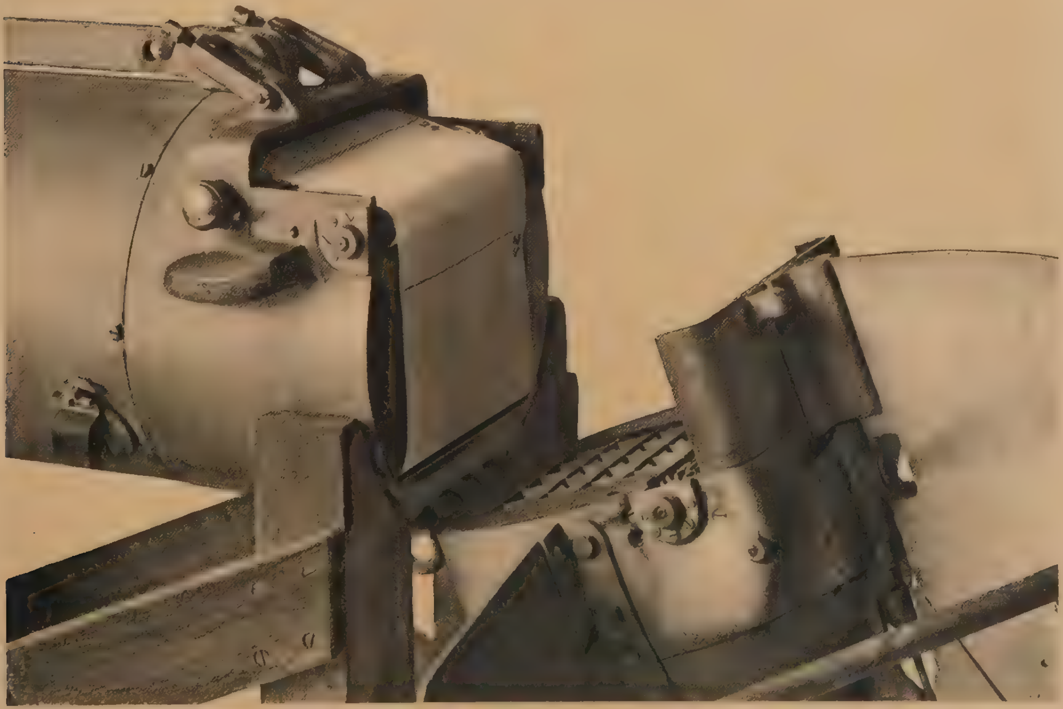

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Fig. 2. The Continuous Plankton Recorder, Type I modified, opened to show the gauze bandings in position.

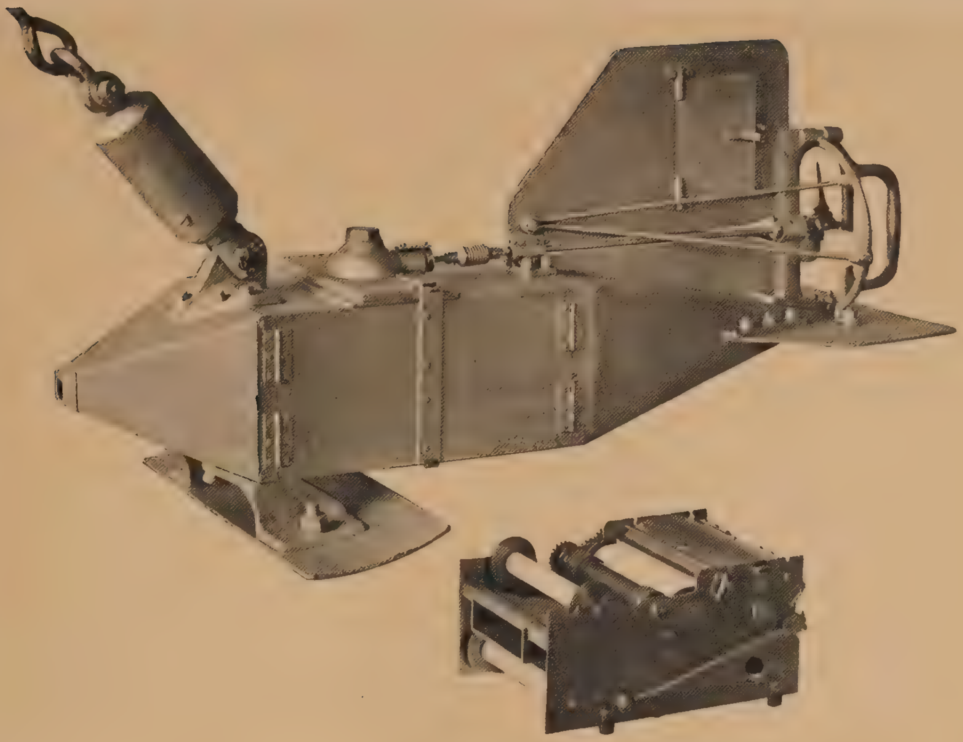

Fig. 1. The Continuous Plankton Recorder, Type II (latest pattern, 1936) seen from the left-hand side, with internal mechanism, loaded with gauze bandings, removed for photographing.

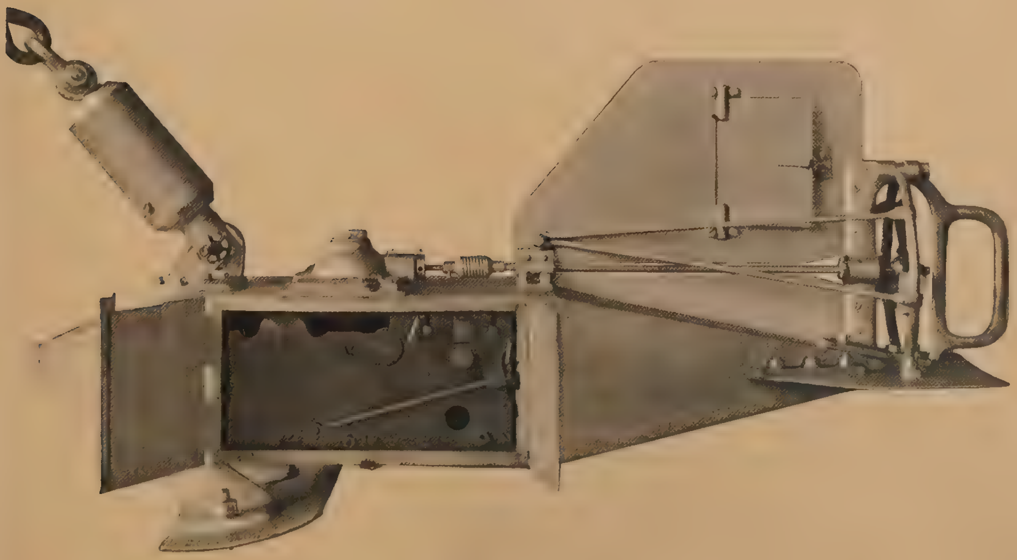

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Fig. 2. The Continuous Plankton Recorder, Type II, with doors opened to show internal mechanism in position.

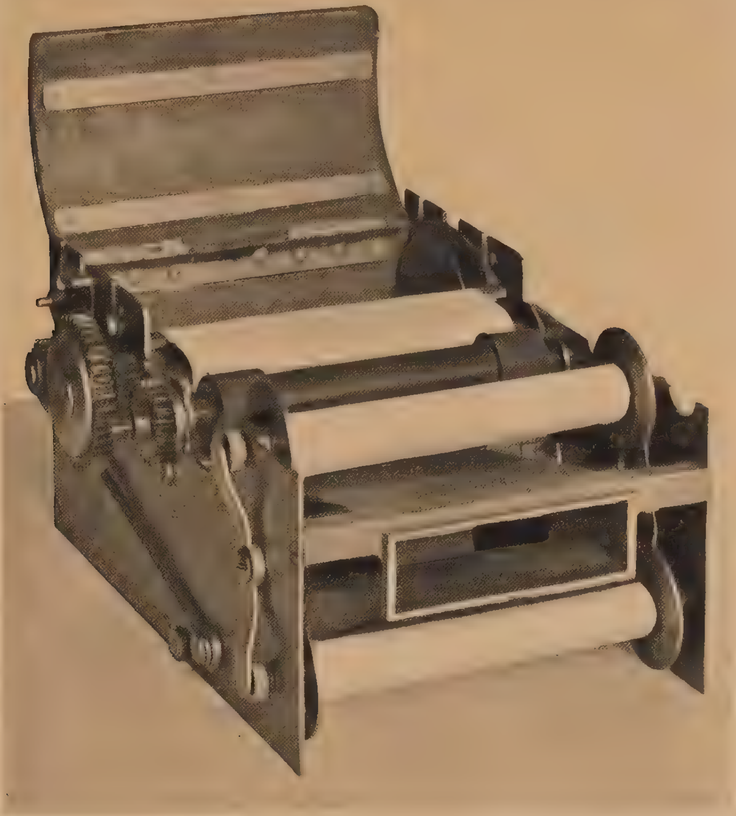

Fig. 1. Internal mechanism of Continuous Plankton Recorder, Type II: right-hand front view showing gauze bandings in position, cross section of water tunnel in front, gear train and friction clutch, and formalin tank opened. (Compare with text-figs. 14 and 16.)

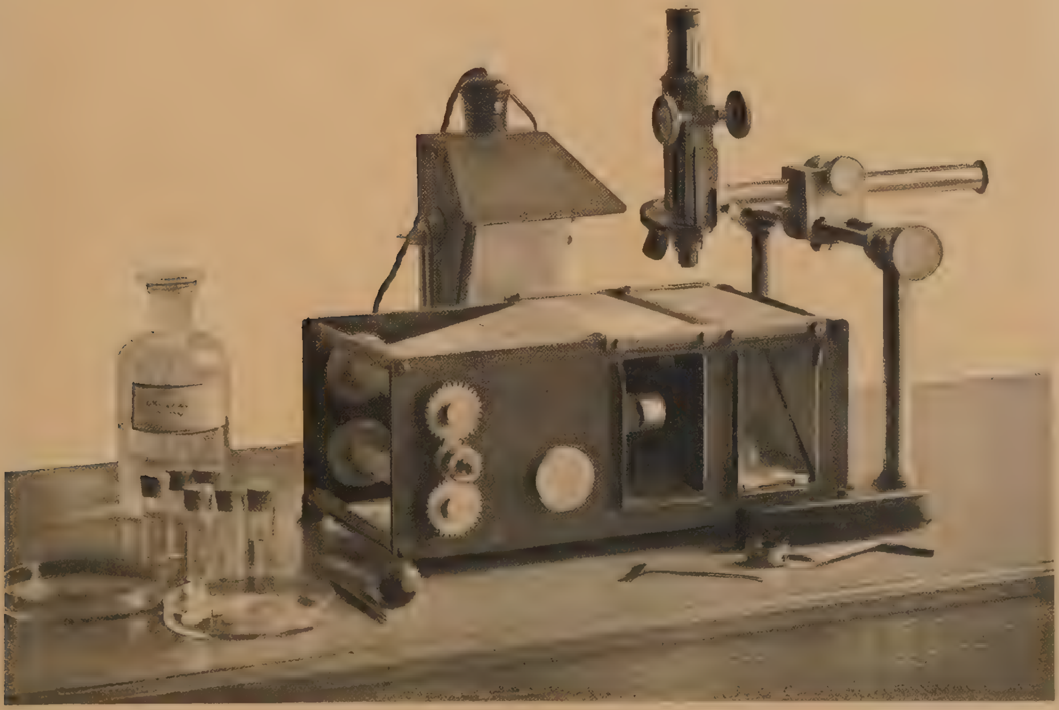

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Fig. 2. Specially designed traversing microscope and stage for examining recorder rolls (see text-fig. 19). The right-hand mirror has been reversed to show reflecting surface. The other is in correct position showing handle for moving it to and fro or tilting it. The simple lens in foreground may be substituted for the compound microscope. A safety-razor blade mounted with handle for removing plankton after examination is also shown in foreground.

[*Discovery Reports. Vol. XI, pp.* 511–538, *November*, 1936.]

OBSERVATIONS ON THE UNEVEN DISTRIBUTION OF OCEANIC PLANKTON

By

A. C. HARDY, M.A.

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and formerly Chief Zoologist, R.R.S. 'Discovery'

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OBSERVATIONS ON THE UNEVEN DISTRIBUTION OF OCEANIC PLANKTON

By A. C. Hardy, M.A.

(Text-figs. 1–18)

INTRODUCTION

It has long been recognized that the marine plankton of coastal regions may be very patchy in its distribution. It is not difficult to understand why this should be so; near the land the sea is frequently and abruptly disturbed over quite small areas by the mixing of oceanic and coastal waters, tidal streams, and the upwelling of lower water layers against coastal banks. The coastal plankton community is further upset by receiving the sporadic outbursts of larval forms from the littoral fauna and the shallow-water benthos. In the open ocean, however, where conditions are more uniform, it has often been assumed that the plankton may remain comparatively constant in quality and quantity over wide areas. Observations on the plankton made on oceanic voyages have usually had to be taken at stations placed at considerable distances apart, so that little evidence has been available as to the evenness or otherwise of the plankton distribution between them.

The supposition that the oceanic plankton is relatively evenly distributed has been widely held under the influence of the theories of Victor Hensen and the Kiel planktologists in spite of the early and vigorous attack by Haeckel (1890) in his *Plankton Studien*. Since the present paper concerns so closely the opposing views of Hensen and Haeckel it may be appropriate to quote the following passage from G. W. Field's translation of the *Plankton Studien* (see literature references):

> *The composition of the plankton is in qualitative as well as quantitative relations very irregular, and the distribution of the same in place and time in the ocean also very unequal.* These two axioms apply to the oceanic as well as to the neritic plankton. In both these important axioms, which in my opinion must form the starting point and the foundation for the *oecology and chorology of the plankton*, are embodied the concordant fundamental conceptions of all those naturalists who have hitherto studied carefully for a long time the natural history of the pelagic fauna and flora.
>
> The surprise was general when Professor Hensen this year advanced an entirely opposite opinion, "that in the ocean the plankton was distributed so equally that from a few hauls a correct estimate could be made of the condition in a very much greater area of the sea".[1] He says himself that the plankton expedition of Kiel, directed by him, started on this "*purely theoretical view*", and that it had "*full results*" because this hypothesis was proven far more completely than could have been hoped.[2]
>
> These highly remarkable opinions of Hensen, contradictory to all previous conceptions, demand

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[1] Victor Hensen, 1890. *Einige Ergebnisse der Plankton-Expedition der Humboldt-Stiftung*. Sitzungsberichte der Berliner Akademie der Wissenschaften vom 13. März, 1890, p. 243.

[2] *loc. cit.* p. 244.

a most thorough investigation; for if they are true then all naturalists who many years previously, and in the most extensive compass, have studied the composition and distribution of the plankton are completely in error and have arrived at entirely false conclusions. If, on the other hand, these propositions of Hensen are false, then his entire plankton theory based thereon falls, and all his painstaking computations are utterly worthless.

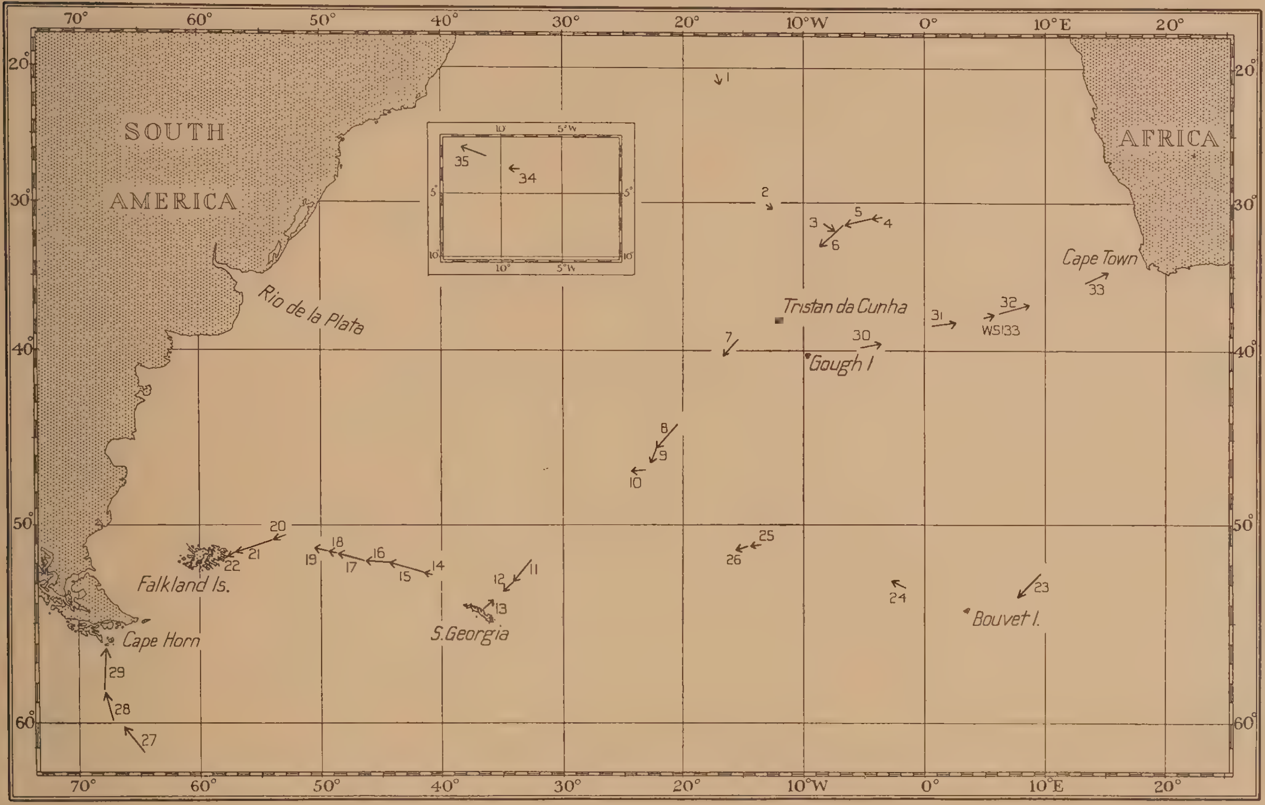
Few will deny the great importance of the work of Hensen and his school in the development of planktology. It was a pity that Haeckel's attack was so bitter and that he did not confine his criticism to the question of irregularity in distribution; as is well known he disputed also one of the most important conclusions of the work of Hensen's Plankton Expedition: that the plankton is on the whole more abundant in the colder and temperate regions than in the tropical seas. Since Haeckel's views on this latter question were shown to be in error, and it was clear that he had misunderstood some of Hensen's other conceptions, his remarks on the uneven distribution of the oceanic plankton lost much of their force.

The records of plankton described in the present paper were taken in the open ocean during the voyages of the R.R.S. 'Discovery' and R.R.S. 'William Scoresby' in the years 1925–7 with the original form of Continuous Plankton Recorder (Hardy, 1926, 1936). They were made with a view to studying the main fluctuations in the planktonic density along uninterrupted lines of observation. These lines varied from 23 to over 100 miles in length and were made in different oceanic regions from the Tropical to the Antarctic Zone. The recorder, the first of its kind, was far from perfect, and frequently the mechanism broke down from one cause or another; but, in all, satisfactory records were obtained covering a total distance of some 2300 miles. The positions of these records are shown in the chart in Fig. 1; they were taken at a depth of between 20 and 30 m.

Whilst quantitative estimates were made, the time available for analysis on the voyage was limited and necessitated broad treatment. The work is intended as a preliminary exploration of the field: to determine the extent of the fluctuations that may be expected in the plankton of different ocean areas and the type of fluctuations found in the main planktonic groups of animals. Only rarely was analysis carried to specific identifications; usually the fluctuations are expressed in terms of numbers of total Chaetognatha, Copepoda, Euphausiacea, etc. The silk gauze used throughout had 60 meshes to the inch, so that only the larger species of phytoplankton were taken when very abundant.

The working of the Continuous Plankton Recorder and the method of examining the samples obtained have already been described in detail (Hardy, 1936), but for convenience may be summarized briefly as follows. When towed, the planes on the machine make it descend to and remain at the required depth, which is governed by the length of the towing line. The water to be sampled flows through a tunnel in the machine, and as it does so a long banding of silk gauze, graduated in numbered sections, winds across the water stream, sieves out the plankton and rolls it up section by section in a preservative chamber. The gauze banding is driven across the water tunnel by the action of a propeller in the passing water outside. The distance travelled by the machine is known from the ship's log, so that the mileage represented by each section on the silk may be determined. After the completion of a run the roll is taken out, placed on a special microscope substage and examined section by section.

The observations made will now each be described briefly in turn, a general discussion on the comparisons and contrasts between different records being reserved till the end.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Rio de la Plata
Falkland Is.
Cape Horn
S.Georgia
Tristan da Cunha
Gough I
Bouvet I.
Cape Town
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Fig. 1. Chart showing the positions of the lines along which continuous plankton records were obtained on the 1925–27 voyages of the R.R.S. 'Discovery' and the R.R.S. 'William Scoresby'. The arrows indicate the direction and length of each record and are numbered in reference to the record numbers in the text. The position of the consecutive net series, WS 133, described on p. 535, is also shown.

OBSERVATIONS

Record 1

Date: 25. xi. 25.
Time: 0920–1700.
Position: 20° 25′ S, 17° 10′ W to 21° 09′ S, 16° 54′ W.
Distance by ship's log: 41·4 miles.

The plankton was very poor in quantity and comparatively even in its distribution. Small Medusae, Chaetognatha, Polychaeta, the gastropod *Ianthina*, Amphipoda, decapod larvae, *Lucifer*, and postlarval fish occurred in isolated ones and twos along the roll. The fluctuations in the number of Copepoda, though small, are shown in Fig. 2 for comparison with other records.

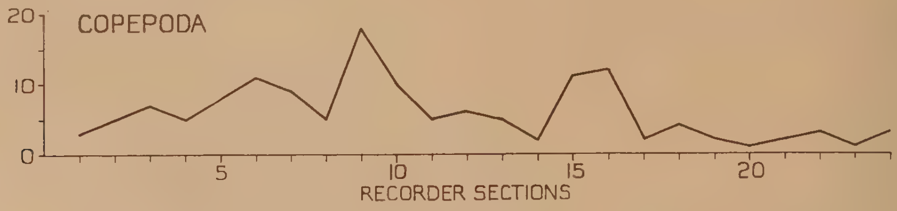

Fig. 2. Variations in the numbers of Copepoda taken on the first continuous plankton record over a distance of 41·4 miles.

RECORD 2

Date: 4. xii. 25.
Time: 0940–1845.
Position: 30° 02′ 50″ S, 13° 06′ 30″ W to 30° 19′ 40″ S, 12° 37′ 30″ W.
Distance by ship's log: 27·4 miles.

Again the plankton was very poor in quantity, except for a remarkably dense and well-defined patch of *Salpa longicauda* some 8 miles across. In this distance over 2300 salps were taken by the recorder, and not a single specimen was found on the roll before or after the patch was encountered. The copepod *Sapphirina*, which is associated with

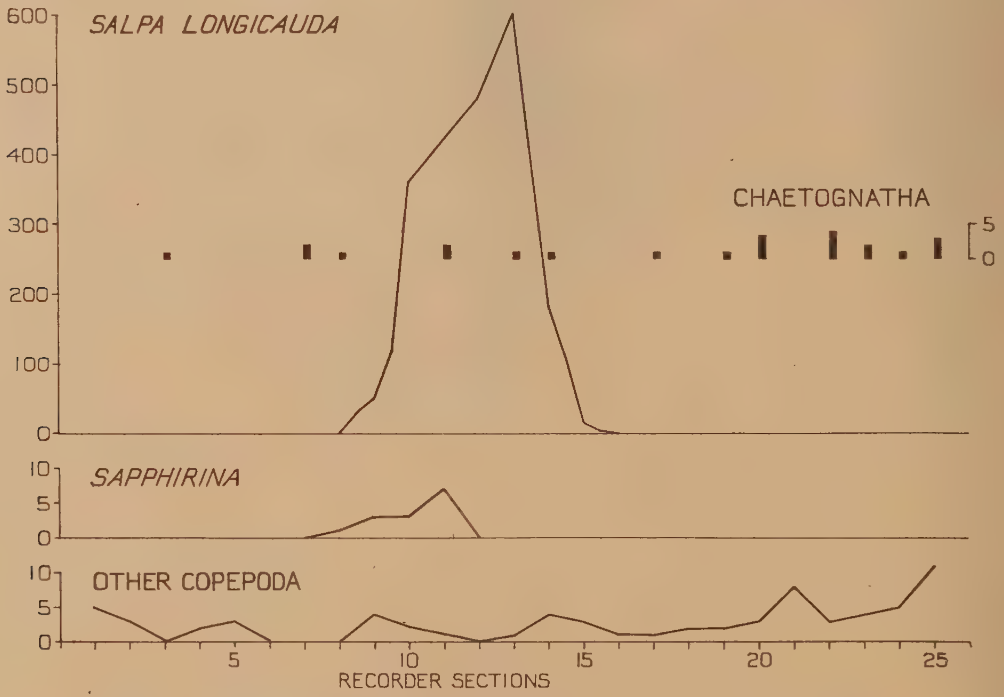

Fig. 3. Variations in the numbers of the predominant plankton organisms on Record 2, taken over a distance of 27·4 miles.

Salpa, is found over half the region of the patch. Whilst the numbers of *Sapphirina* are too small to be of much significance they may suggest that the *Salpa* patch is being invaded by the copepod from one side. Fig. 3 shows their distribution together with that of other Copepoda and Chaetognatha.

Globigerina, small Medusae, Diphyidae, Polychaeta, Ostracoda, Amphipoda, decapod larvae and young Euphausiacea occurred in isolated ones and twos along the roll.

RECORD 3

Date: 9. xii. 25.
Time: 0900–1815.
Position: 31° 12′ 35″ S, 8° 00′ 30″ W to 31° 45′ 00″ S, 7° 10′ 30″ W.
Distance by ship's log, 50·6 miles.

The plankton was again poor, but the record showed an interesting change in composition at sections 14–15 as if passing from one hydrological zone to another. *Doliolum* the gastropod *Ianthina*, and the copepod *Candacia ethiopica* all came to an end together and *Calanus robustior* appeared on the roll. Their distribution, together with that of other Copepoda and young Euphausiacea, is shown in Fig. 4. Diphyidae, Polychaeta,

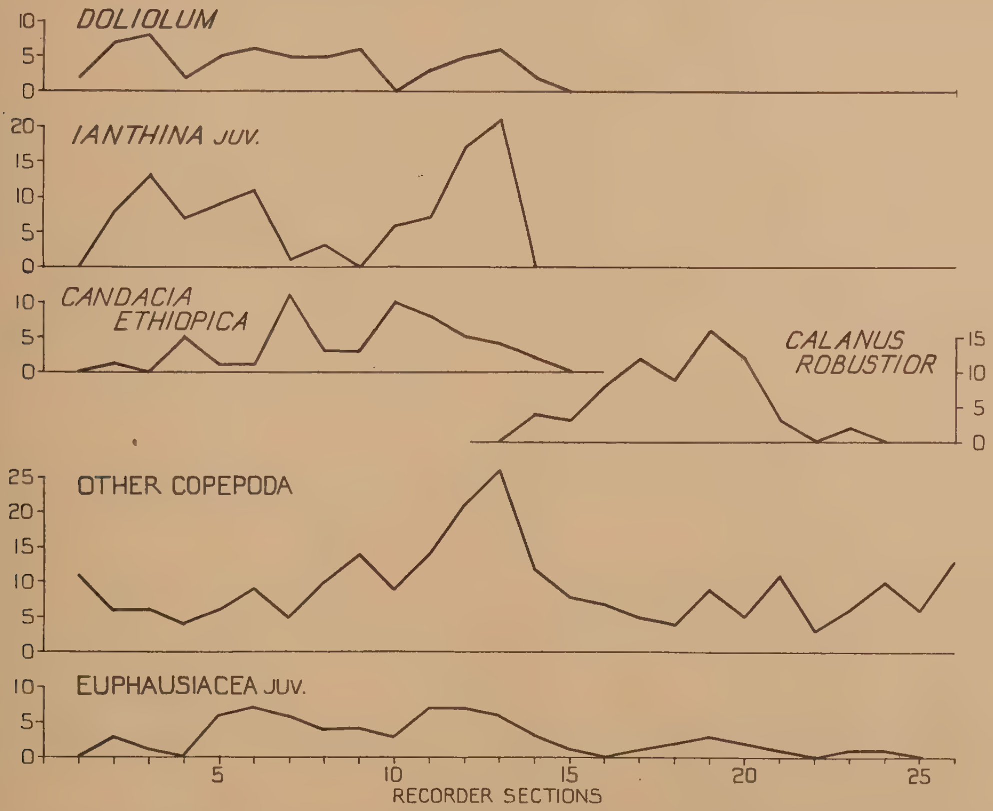

Fig. 4. Variations in the numbers of the predominant plankton organisms on Record 3, taken over a distance of 50·6 miles. Note the changes in the plankton community about recorder sections 13–15.

Chaetognatha, Ostracoda, Amphipoda, the pteropods *Limacina* and *Clio*, and young fish occurred in small numbers along the roll.

RECORDS 4 AND 5

Date: 25–26. i. 26.
Time: 1117–1830 and 1845–1730.
Position: 31° 07′ S, 3° 29′ W to 31° 32′ S, 6° 40′ W (approx.).
Distances by ship's log: 43·3 and 120 (approx.) miles.

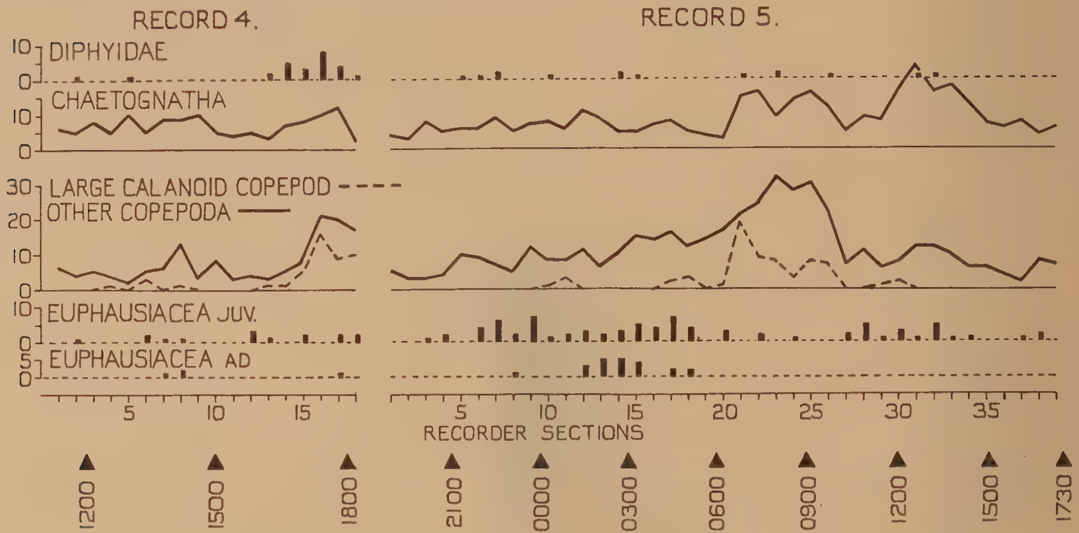

Fig. 5. Variations in the numbers of the predominant plankton organisms on Records 4 and 5 taken over distances of 43·3 and 120 (approx.) miles respectively. A time scale (blacked in triangles) is provided below the graphs.

RECORD 6

Date: 26–27. i. 26.
Time: 1855–1800.
Position: 31° 32′ S, 6° 40′ W to 32° 56′ S, 8° 37′ W.
Distance by ship's log: 121·1 miles.

These three records, 4, 5 and 6, form a continuous series in the South Atlantic to the north-east of Tristan da Cunha. Record 6, which was badly preserved, will be dealt with separately. Fig. 5 shows the fluctuations in the more important forms on Records 4 and 5: Diphyidae, Chaetognatha, Copepoda, Euphausiacea and their larvae. We may note the small concentration of Diphyidae, the larger numbers of Copepoda taken between 1700 and 1800 and between 0700 and 0900, and the larger numbers of Euphausiacea taken at night, no doubt due to vertical migration.

Record 6 was a trial made without using the covering roll soaked in formalin, and it was found that the majority of organisms were decomposed beyond recognition and a quantitative estimate was impossible. The Euphausiacea and their larvae, however, could be counted and are shown in Fig. 6, together with a very rough indication of the

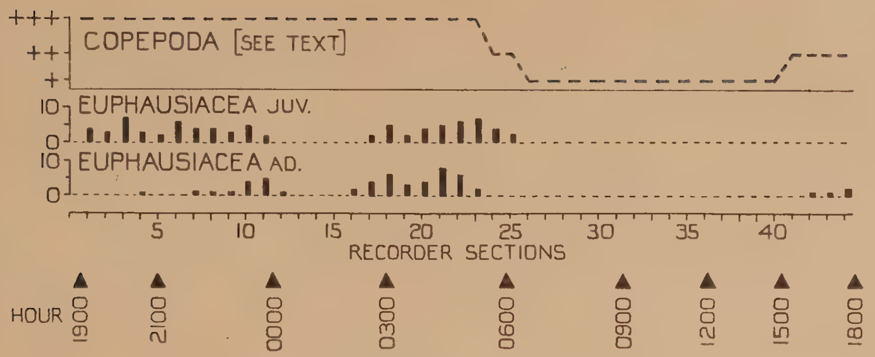

Fig. 6. Variations in the numbers of Copepoda and Euphausiacea on Record 6 taken over a distance of 121·1 miles

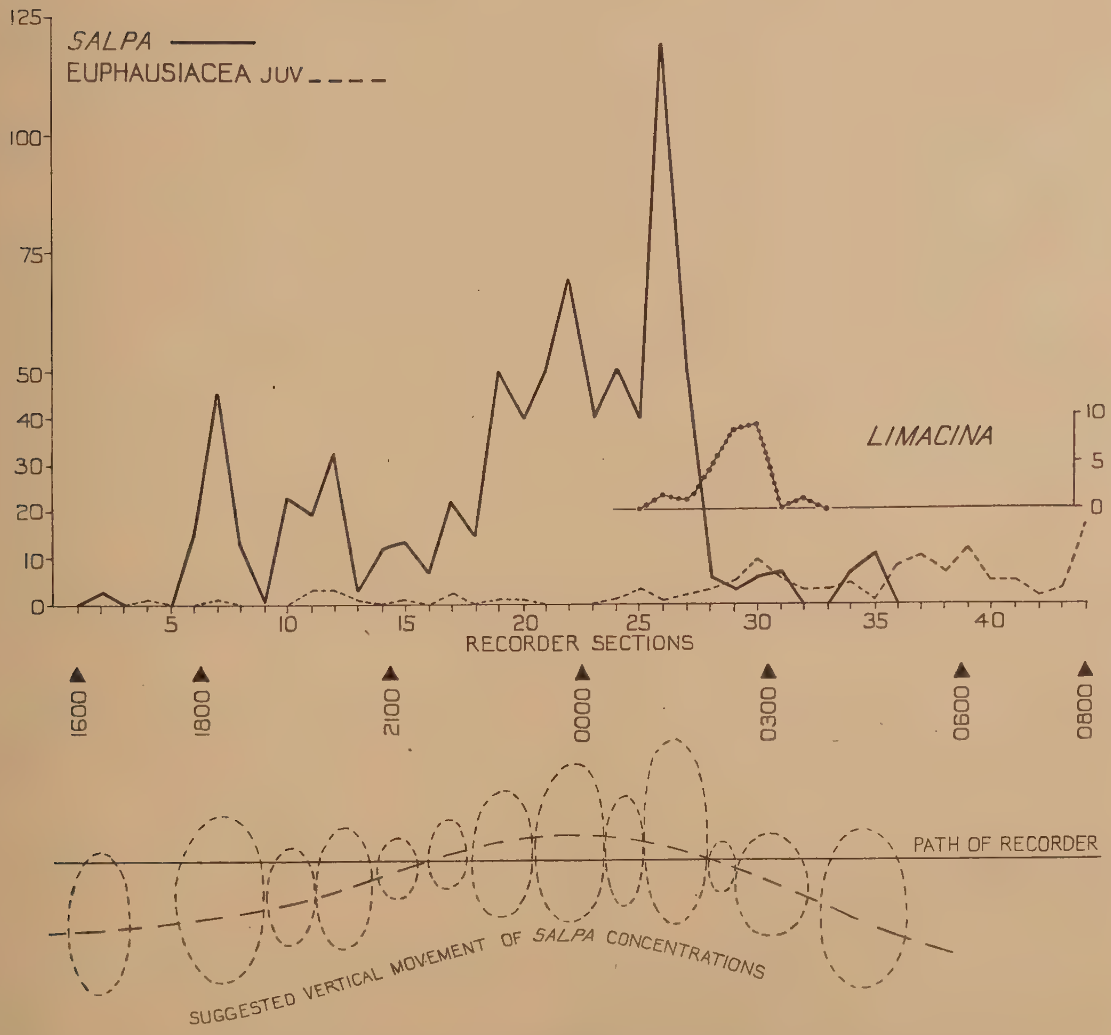

Fig. 7. Variations in the numbers of the predominant plankton organisms on Record 7 taken over a distance of 91 miles. A time scale (black in triangles) is provided below the graph and below this is a diagram to illustrate the suggested vertical movements of the *Salpa* concentrations encountered.

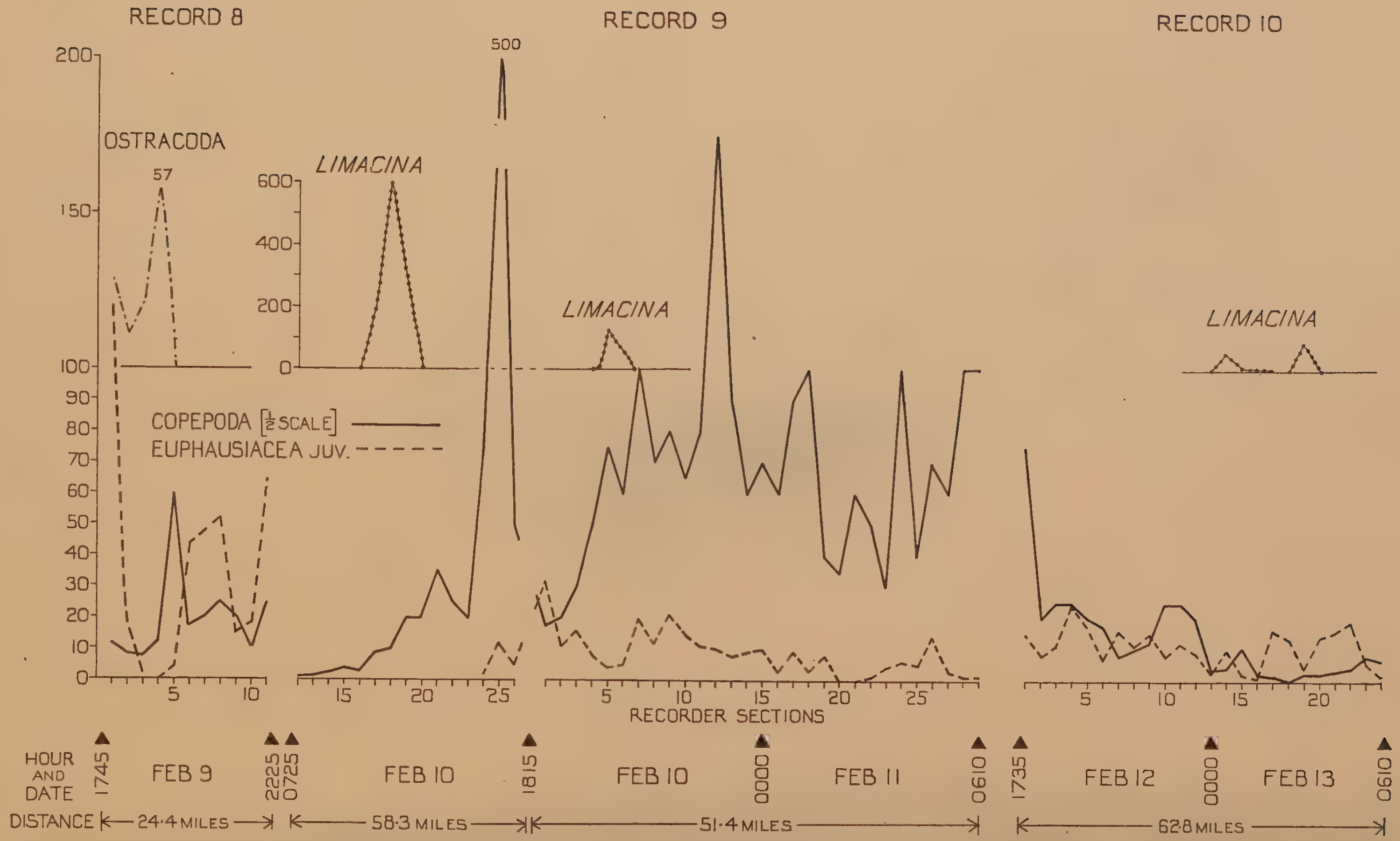

Fig. 8. Variations in the numbers of the predominant plankton organisms on Records 8, 9 and 10.

quantities of Copepoda which were recorded with symbols indicating "few", "fair numbers" and "many". Both they and the Euphausiacea show evidence of vertical migration. It is possible that the increase in the Copepoda in Records 4 and 5 in the evening and the morning may indicate a vertical migration. Between 1700 and 1800 a number may have risen from below and be crossing the path of the recorder (20 m. depth), remaining above the recorder during the night and again (their representatives further on) sinking across the path of a recorder in the morning between 0700 and 0900.

RECORD 7

Date: 6–7. ii. 26.
Time: 1550–0835.
Position: 39° 12′ S, 15° 20′ W to 40° 22′ S, 16° 36′ W.
Distance by ship's log: 91 miles.

This record is interesting for its distribution of *Salpa* and *Limacina* shown in Fig. 7. The numbers of *Salpa* fluctuate in a series of waves with main peaks at sections 7, 12, 19, 22 and 26, approximately 10, 14, 6 and 8 miles apart. There are lesser peaks in between and there is a gradual increase in abundance up to section 26 and then a rapid decline in numbers. Considered in relation to the time scale this increase suggests the upward vertical migration of the animal, patchy in distribution, coming more and more into the path of the instrument to reach a maximum after midnight and then sink more rapidly in the early morning. The small increases at sections 2 and 35 might thus represent the fringes of larger concentrations lower down. This suggested vertical migration of patches is indicated in a diagram below the graph in Fig. 7 and should be compared with the figure of vertical migration of *Salpa fusiformis* in Hardy and Gunther (1935, fig. 123). Also the size of the patches is similar to that found for *S. fusiformis* at South Georgia by consecutive net observations (*loc. cit.*, fig. 135). This combined effect of vertical migration and patchiness was suggested by Hardy and Gunther to account for the distribution of *Euphausia superba* in the consecutive net series (*loc. cit.*, fig. 136).

The pteropod *Limacina* occurred in an isolated patch some 16 miles across, increasing in concentration towards its centre. Such isolated patches of *Limacina*, as we shall see, are not uncommon features of the oceanic plankton. The distribution of young Euphausiacea is also shown in Fig. 7. The copepod population was exceedingly scanty, never exceeding four per section. Chaetognatha, Ostracoda, Amphipoda, decapod larvae and postlarval fish occurred in small numbers.

RECORDS 8, 9 AND 10

Dates: 9–13. ii. 26.
Times: see Fig. 8.
Position: 44° 03′ S, 20° 20′ W to 52° 52′ S, 34° 03′ W.
Distance: 196·9 miles (see Fig. 8).

Except for a break in record 8 (2235–0735 o'clock) and between records 9 and 10, when deep-water nets were being used, the three records form a continuous series. The main features are shown in Fig. 8. A single isolated concentration of Ostracoda and four concentrations of *Limacina* are conspicuous. The Copepoda present a series of wave-like fluctuations along the whole course of the records. During the night of February 10–11 there is a general increase in the Copepoda, reaching a maximum about midnight; whilst this may well be due to vertical migration, there is a well-marked fluctuation superimposed upon this general increase. The densest concentration of Copepoda occurred at 1700 o'clock on the 10th. During the night of February 12–13 the numbers of Copepoda were nothing like so high as those for the 10th–11th, but the young euphausians were as well represented. Chaetognatha, Amphipoda and larger Euphausiacea were taken in small numbers.

RECORDS 11 AND 12

Dates: 18–19. ii. 26.
Times: 2310–1330 and 1500–2000.
Position: 51° 57′ S, 32° 31′ W to 53° 21′ S, 34° 53′ W.
Distance by ship's log: 109·4 miles.

These two records form a continuous series in a line approaching South Georgia from the north-east, broken only by an interval in time when the ship stopped for soundings (1330–1500). The records show (Fig. 9) a dense belt of the diatom *Thalassiothrix antarctica* stretching for 75 miles and followed by a small but almost equally dense patch some 12 miles farther on. An interesting feature of the record is the dense concentration of the larval Euphausiacea which occurred in the gap between the two patches of phytoplankton. The significance of the inverse correlation between the phyto- and the zooplankton has been discussed at length by the author recently (in Hardy and Gunther, 1935). In this record it is impossible to decide whether the concentration of the euphausians is to be attributed to an exclusive influence of the phytoplankton or

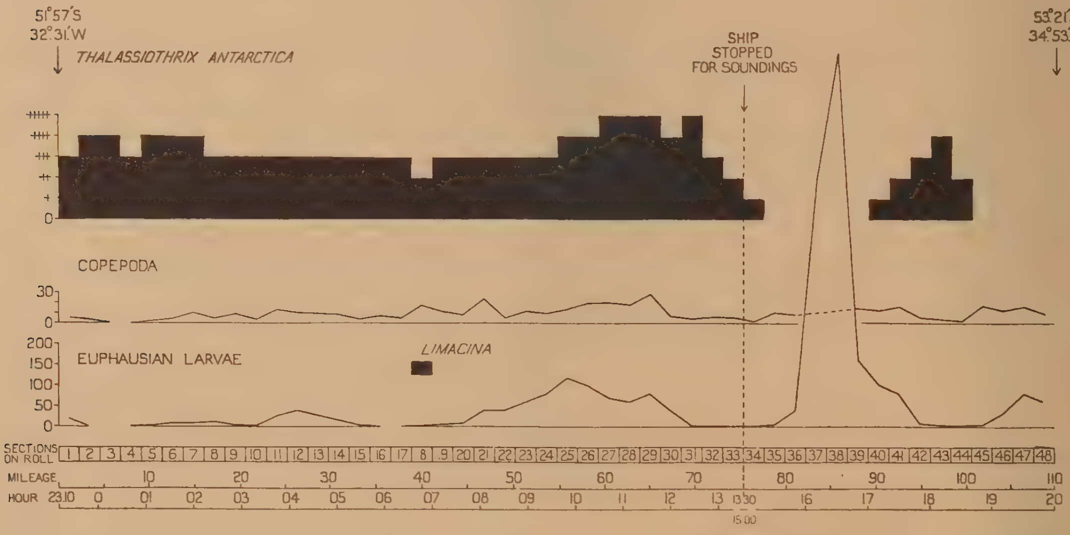

Fig. 9. Variations in the numbers of the predominant plankton organisms on Records 11 and 12; the division between these records where the ship stopped for soundings is indicated by the vertical broken line.

whether the gap in the phytoplankton is due to the grazing action of the large number of euphausians. The concentration of euphausians cannot be only an apparent one due to a possible reduced filtration on the other parts of the roll caused by the phytoplankton; if this were so the concentration would begin as soon as the phytoplankton becomes reduced. A small isolated patch of *Limacina* is also a feature of the record. The Copepoda were never abundant. Hyperiid amphipods were taken in isolated ones and twos along the roll.

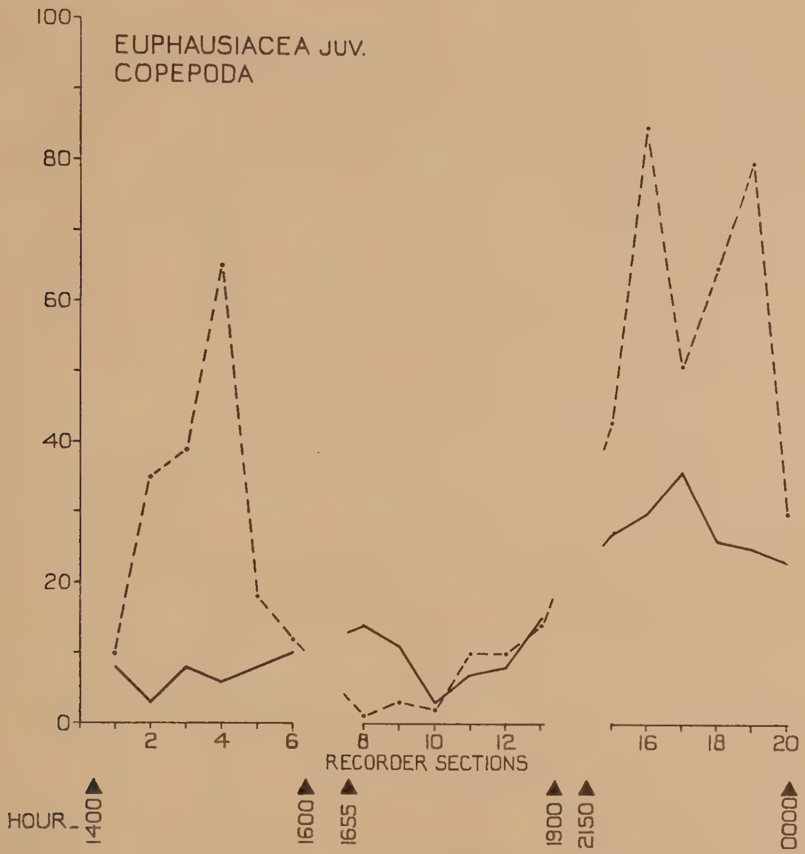

Fig. 10. Variations in the numbers of the predominant plankton organisms, Copepoda *continuous line* and Euphausiacea juv. *broken line*, on Record 13 taken between four stations off the north-east coast of South Georgia along a total distance of 30·6 miles.

RECORD 13

Date: 3. iii. 26.
Times: 1400–0000 (see Fig. 10).
Position: 15·4 to 46 miles N 46° E of Jason Light, South Georgia.
Distance: 30·6 miles.

This record is taken under coastal rather than oceanic conditions, being run between four stations off the north-east coast of South Georgia. It shows well (Fig. 10) the patchy nature of the distribution of young euphausians. The Copepoda show a general increase with the approach of night.

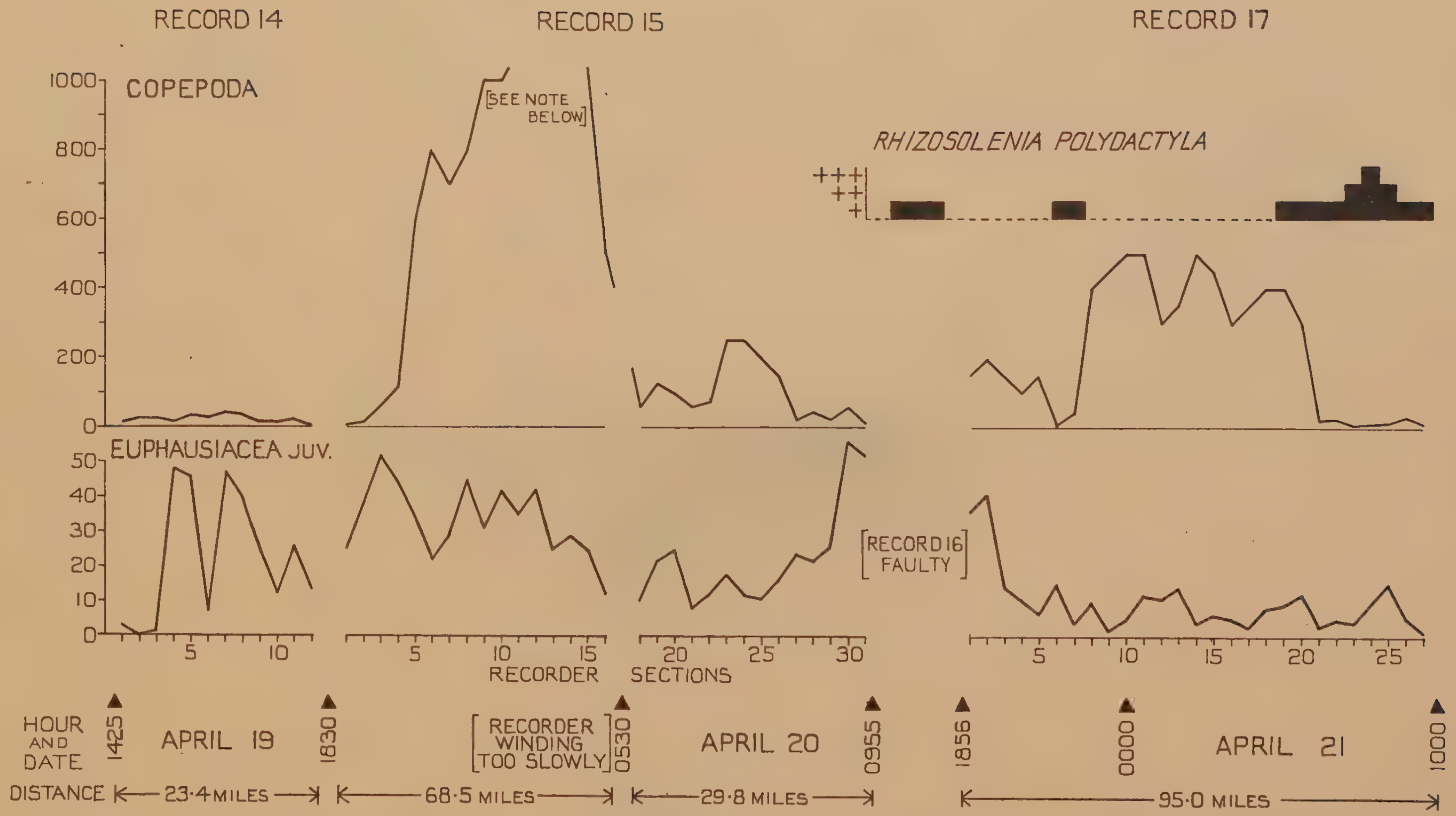

Fig. 11 (continued on opposite page). Variations in the numbers of the predominant plankton organisms on Records 14 to 22.

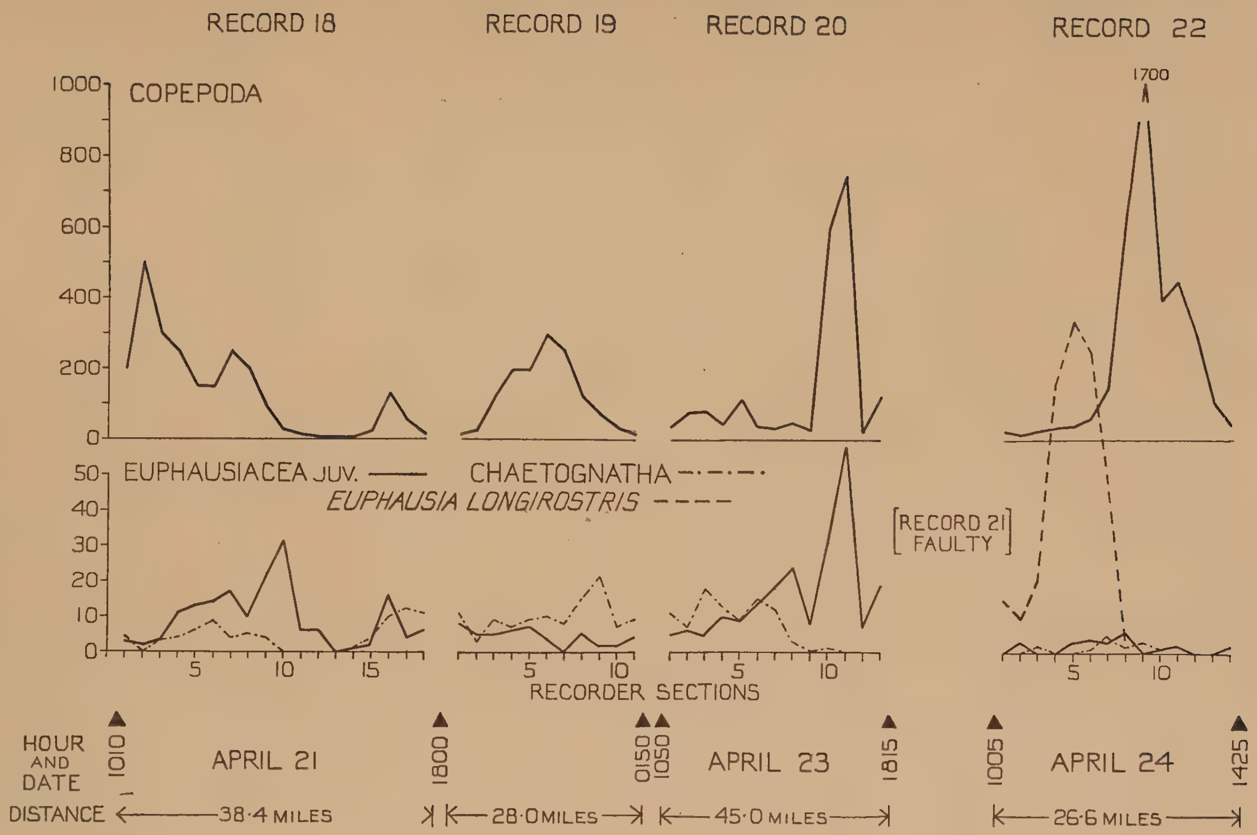

Fig. 11 (*continued*).

RECORDS 14–22

Dates: 19–24. vi. 26.
Times: see Fig. 11.
Position: 52° 30′ S, 40° 46′ W to 51° 32′ S, 57° 36′ W.
Distance: see Fig. 11.

These records form a series on a line between South Georgia and the Falkland Islands. Records 16 and 21 were faulty, and between records 19 and 20 there is a gap of some 50 miles, otherwise they form a continuous series between the positions given. The total distance recorded was 497·4 miles.

The outstanding feature of these records (Fig. 11) is the marked fluctuation in the numbers of Copepoda. It seems likely that some of these increases must be attributed to vertical migration; thus the concentration between sections 3 and 20 on record 15 and between 7 and 21 on record 17 occurred during periods of night. Record 16 was taken during the day, and although the mechanism jammed and failed to wind on properly, the part of the gauze exposed throughout the run showed that the numbers of Copepoda were small. Records 18, 20 and 22, on the other hand, showed dense concentrations in the daytime and record 19 another at night. Apart from the possible effects of vertical migration the records demonstrate a marked unevenness in the distribution of the copepod population over a wide ocean area. Record 21 (omitted in the figure) could not be estimated quantitatively; owing to a mechanical defect the storage roller was wound so tightly that the plankton was rubbed and pressed into a fine paste. It was evident, however, that throughout the roll there was a thick deposit of Copepoda and young Euphausiacea. Young Euphausiacea were present on all records and showed a marked degree of fluctuation. Adult *Euphausia longirostris* formed a well-defined patch some 8 miles across on record 22. Chaetognatha were all but absent from records 14–17, but present in small fluctuating numbers on records 18–22. The diatom *Rhizosolenia polydactyla* formed three patches, one covered by the faulty record 16.

RECORD 23

Dates: 13–14. xi. 26.
Times: 1500–2030 and 0800–1700.
Positions: 52° 29′ S, 9° 48′ E to 52° 37′ S, 9° 36′ E and 53° 08′ S, 8° 44′ E to 53° 37′ S, 7° 45½′ E.
Distances by ship's log: 12·8 and 43·75 miles.

RECORD 24

Dates: 19–20. xi. 26.
Times: 1055–2020 and 0800–2100.
Positions: 53° 06′ S, 1° 29′ W to 53° 02′ S, 1° 56′ W and 53° 02′ S, 2° 25′ W to 52° 47′ S, 2° 41′ W.
Distances by ship's log: 19·7 and 24·5 miles.

These records are included on account of the dense concentrations of phytoplankton met with and the scarcity of zooplankton. The phytoplankton could not be estimated accurately, but five degrees of density were indicated by a system of + signs. These approximate values, also for *Globigerina* and Radiolaria, are blocked in as histograms in Fig. 12. Record 23 was interrupted; after recording for only three sections it was taken inboard at 2030 owing to ice conditions and put out again at 0800 the following morning. Phytoplankton was dense on the first three sections; next morning it was almost absent for some 18 miles, when it appeared again in small quantities until towards the end of the record where it increased greatly. Record 24 was also interrupted during the night on account of difficult ice conditions. Phytoplankton was dense throughout the record except for a few miles at the beginning of the renewed run. Copepoda were absent from record 24 and all but absent from the dense phytoplankton zones at the beginning and end of record 23; they were present, however, in fair numbers (see Fig. 12) in the region of poor phytoplankton over the greater part of record 23. To what extent does this distribution support the inverse relationship between zoo- and phytoplankton discussed by the author in the former report (Hardy and Gunther, 1935)? Can the reduced number of Copepoda in the zones of dense phytoplankton be entirely due to the loss of filtration by the silk becoming clogged with the diatoms? To some extent this must

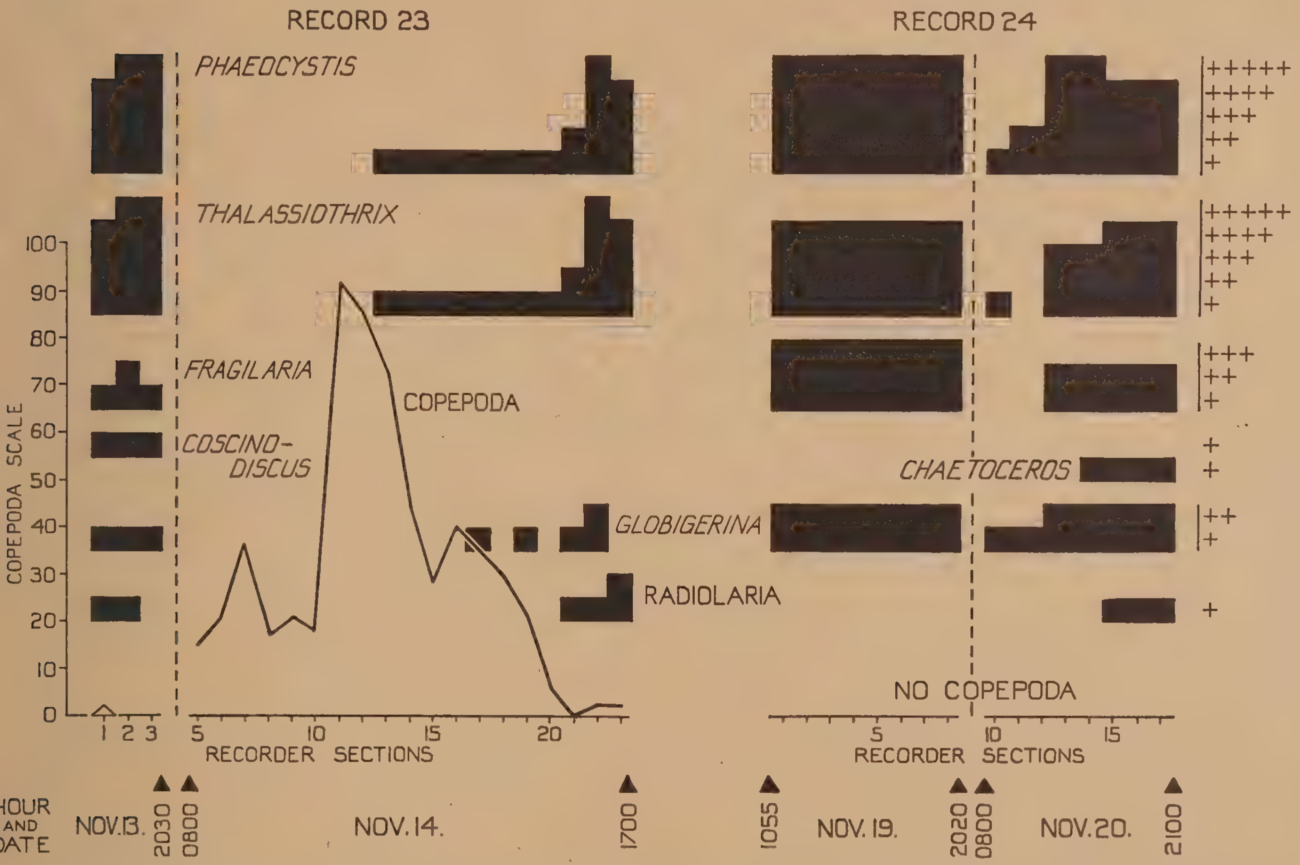

Fig. 12. Variations in the quantities of the predominant plankton organisms on Records 23 and 24. Except for Copepoda the relative abundance of organisms is shown by a scale of + signs: +, + +, + + + ...

occur, but if it was simply a question of reduced filtration then we should expect to find copepods recorded in the short region of poor phytoplankton in record 24, but we do not. Only isolated specimens of Euphausiacea, pteropods (*Clione*) and *Tomopteris* were recorded.

Record 25

Date: 26. xi. 26.
Time: 1212–2050.
Position: 51° 02′ S, 13° 26′ W to 51° 05′ S, 14° 21′ W.
Distance by ship's log: 35·3 miles.

Record 26

Date: 27. xi. 26.
Time: 1225–2050.
Position: 51° 15′ S, 14° 41′ W to 51° 17′ S, 15° 33′ W.
Distance by ship's log: 40·6 miles.

These two short records were taken over the same period of the day on two consecutive days. They are shown in Fig. 13. They both show a great increase in the number

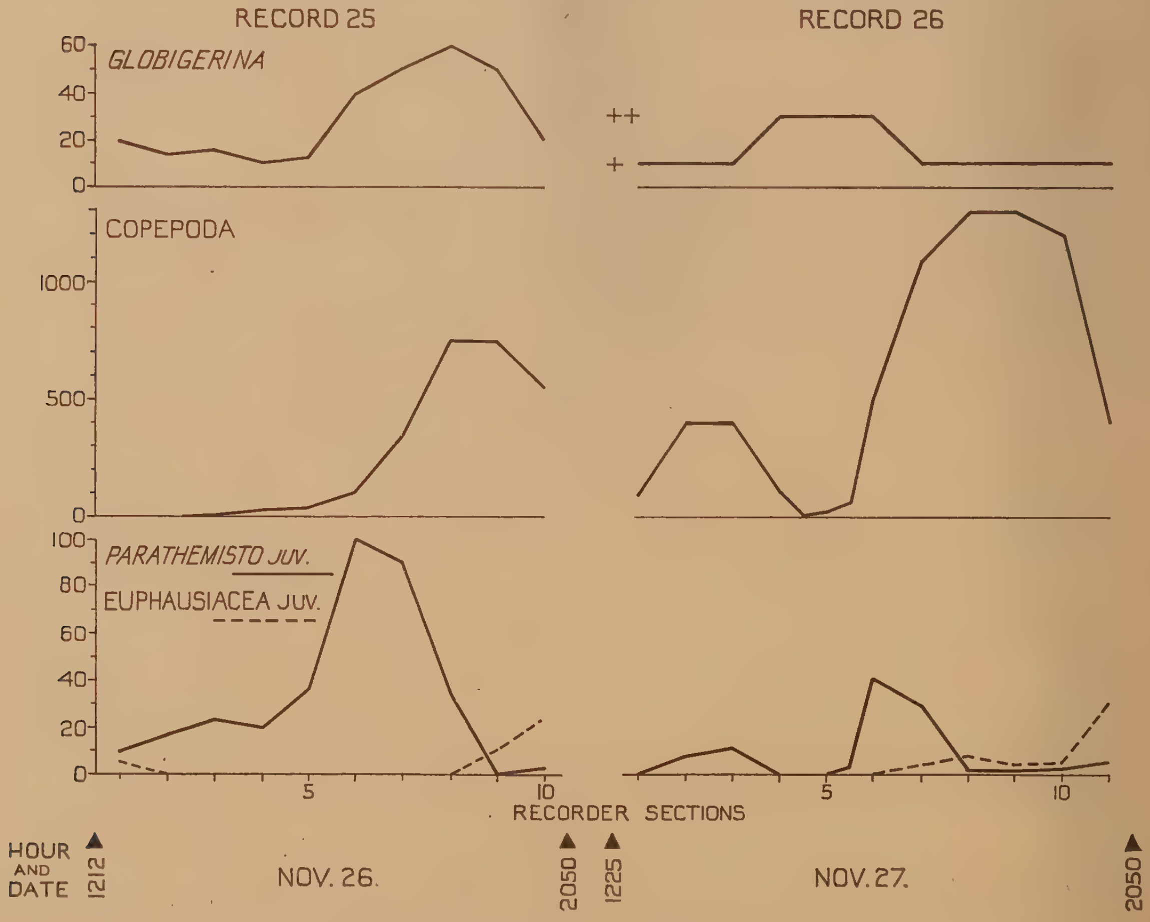

Fig. 13. Variations in the numbers of the predominant plankton organisms on Records 25 and 26

of Copepoda at the approach of evening, but on record 26 there is a well-marked zone of scarcity between two concentrations. The young of the hyperiid amphipod *Parathemisto* form a dense concentration in each record at about the same time of the day; this suggests that perhaps they are migrating upwards at the same times and passing the path of the recorder into the surface waters above it. Fluctuations in *Globigerina* are shown in each record. Euphausiacean larvae occur and increase towards the end of each record.

RECORDS 27, 28 AND 29

Dates: 16–22. iv. 26.
Times: see Fig. 14.
Position: Drake Strait: 61° 15′ 00″ S, 64° 42′ 50″ W to 56° 11′ 40″ S, 67° 32′ 30″ W.
Distances: see Fig. 14.

These three records form an almost complete line of observation between the Discovery Stations 212–221 across the Drake Strait in the direction South Shetlands to Cape Horn. The only gap in the series is a distance of 31 miles between Sts. 214 and 215, when the state of the sea was force 7 and the recorder was not used. A violent storm caused a delay at St. 218, the working of which was unsatisfactory; it was repeated as St. 219 when the weather had moderated. Thus the series is broken in time between Sts. 218 and 219 but not in space. St. 218 was begun at noon on April 19 and St. 219 finished at 1800 on April 21. The total distance recorded in this series is 273·5 miles. The fluctuations in the more important organisms, the times and the distances are shown in Fig. 14. The positions are shown in the chart in Fig. 1. The line of the Antarctic convergence, which separates the surface waters of the Antarctic from those of the sub-Antarctic Zone, passes between Sts. 215 and 216. At about this point we see a broad belt of the diatom *Thalassiothrix antarctica* giving place to one of *Rhizosolenia styliformis*, the two occurring together for a distance of some 20 miles.

The distribution of the pteropod *Limacina* extends over almost all the line of the Antarctic Zone but also penetrates a little way into the sub-Antarctic water. Its numbers show very pronounced fluctuations.

There is a remarkable general correspondence between the increase and decline in the Chaetognatha and Copepoda. Both groups, however, show in detail considerable fluctuations and often the numbers of the two fluctuate in reverse directions. This is particularly so between Sts. 219 and 221, also to some extent between Sts. 215 and 216. Since it is known that copepods often form an important element in the diet of chaetognaths, at first sight these reverse fluctuations might suggest that they are being grazed down where the chaetognaths are more concentrated, whilst at other points, as between Sts. 217 and 218, the Copepoda have outstripped the chaetognath numbers. But when we consider the actual numbers involved such an interpretation would only be tenable if the chaetognaths very rarely fed upon copepods of the size sampled. The numbers of the two groups sampled are approximately equal. The chaetognaths must be subsisting

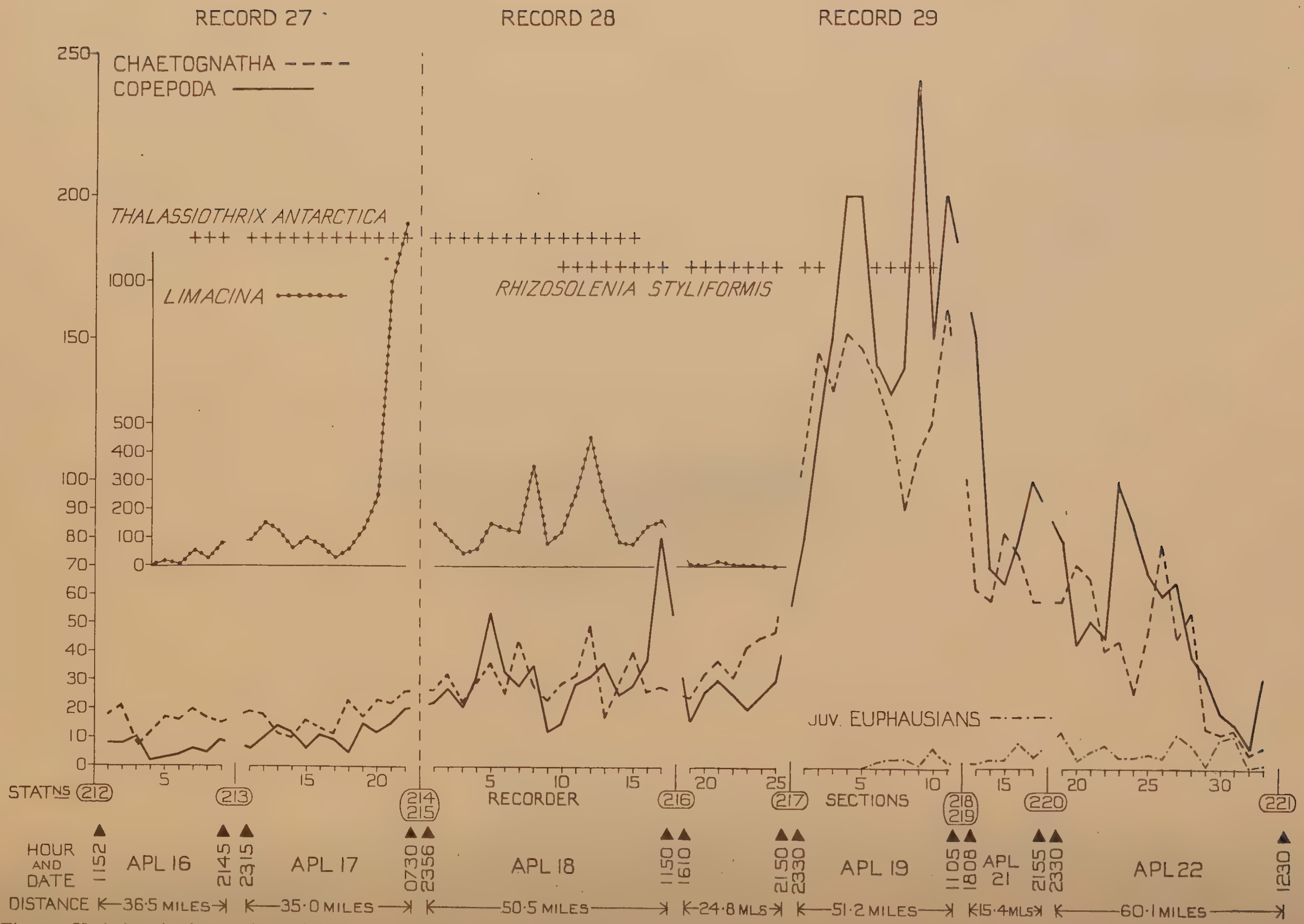

Fig. 14. Variations in the numbers of the predominant plankton organisms on Records 27, 28 and 29 taken on a line across the Drake Strait in the direction South Shetlands to Cape Horn.

largely on other food, possibly upon smaller species of copepod or younger stages which pass through the mesh of the recorder.

The young Euphausiacea were never abundant in the series. Isolated specimens of *Parathemisto*, *Euphausia triacantha* and *E. frigida* were taken south of the Antarctic convergence and *E. spinifera* to the north of it.

RECORD 30

Date: 12. vi. 27.
Time: 1202–2050.
Position: 39° 52′ S, 5° 18′ W to 39° 35′ S, 3° 33′ W.
Distance by ship's log: 81·9 miles.

RECORD 31

Dates: 13–14. vi. 27.
Time: 2243–0930.
Position: 38° 21′ S, 0° 42½′ E to 38° 4′ S, 2° 45′ E.
Distance by ship's log: 107·8 miles.

RECORD 32

Date: 15. vi. 27.
Time: 0955–2055.
Position: 37° 34′ S, 6° 09′ E to 36° 57′ S, 8° 44½′ E.
Distance by ship's log: 108·7 miles.

RECORD 33

Dates: 16–17. vi. 27.
Time: 2300–1100.
Position: 35° 28½′ S, 13° 09¼′ E to 34° 46¼ S, 15° 17¾′ E.
Distance by ship's log: 124·1 miles.

These four records were taken from the R.R.S. 'William Scoresby' on a voyage across the South Atlantic Ocean between Gough Island and Cape Town. The outstanding features are illustrated in Figs. 15 and 16. Throughout the series there is a remarkable contrast between the abundance of Copepoda during the night and their scarcity or absence during the day. This must undoubtedly be attributed to vertical migration. Nevertheless, on top of these general migrational increases a number of marked fluctuations in numbers are revealed. *Limacina* occurs in well separated zones and small salps extend in a patch of some 36 miles but are taken nowhere else on the records. The young Euphausiacea show increases during the night in records 30, 31 and 32, but in record 33 they are taken in larger numbers in the daytime.

RECORD 34

Date: 19. viii. 27.
Time: 0930–1800.
Position: 2° 50′ S, 8° 30′ W to 2° 49½′ S, 9° 25½′ W.
Distance by ship's log: 40·7 miles.

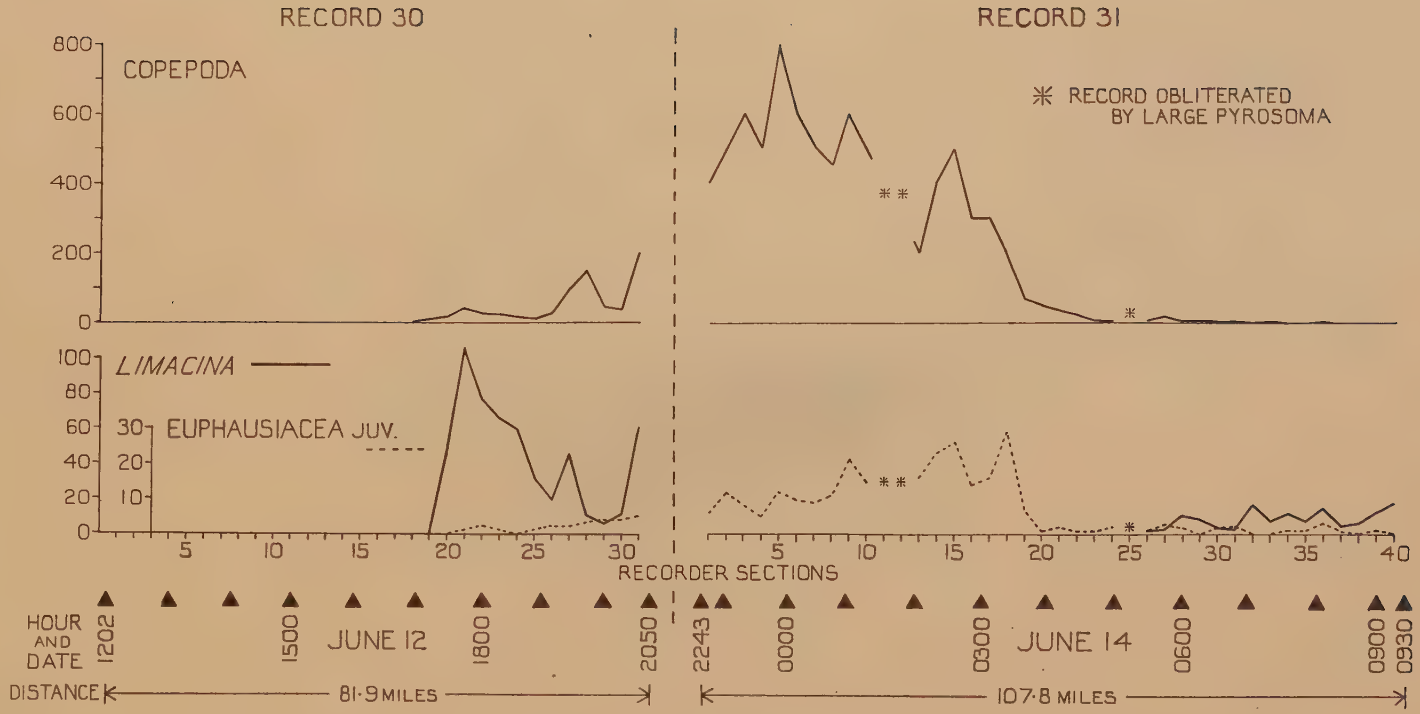

Fig. 15. Variations in the numbers of the predominant plankton organisms on Records 30 and 31.

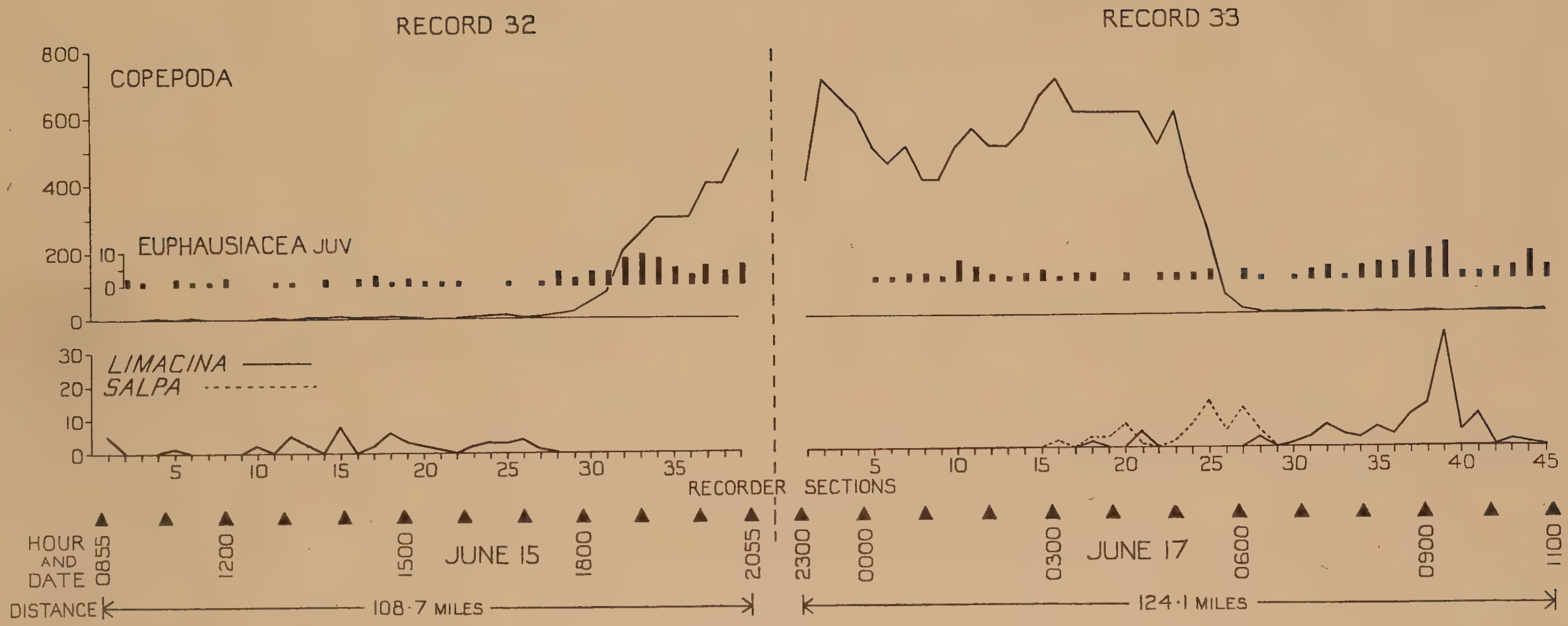

Fig. 16. Variations in the numbers of the predominant plankton organisms on Records 32 and 33.

RECORD 35

Dates: 20–21. viii. 27.
Time: 1800–0530.
Position: 01° 50′ S, 11° 15′ W to 01° 07′ S, 13° 12′ W.
Distance by ship's log: 75·6 miles.

These two records were taken on the homeward voyage of the R.R.S. 'Discovery' just south of the equator (see Fig. 1). The fluctuations in the Copepoda, Chaetognatha, and young Euphausiacea are shown for both records in Fig. 17, and in addition in record 35 are shown the numbers of Diphyidae and the copepod *Labidocera acutifrons*. Isolated specimens of ostracods, amphipods, pteropods, small cephalopods, young fish and salps are not shown.

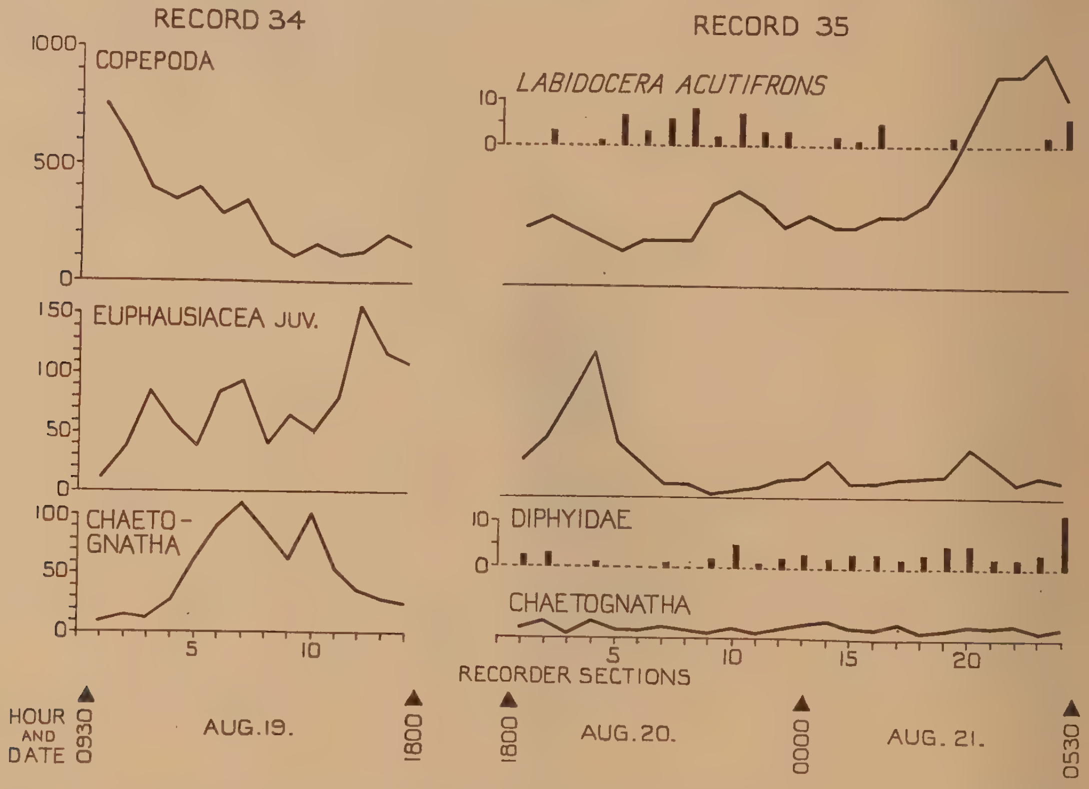

Fig. 17. Variations in the numbers of the predominant plankton organisms on Records 34 and 35 taken along distances of 40·7 and 75·6 miles respectively.

DISCUSSION

First of all it is necessary to be satisfied that the fluctuations observed are real ones in the sea and not an artifact due to an erratic behaviour in the recording mechanism. Usually a failure in the mechanism results in a complete stoppage, but occasionally the winding may continue for a time at a slower speed before stopping; but such failures are exceptional and detectable (see record 15 in Fig. 11). A consideration of the records obtained shows clearly that the fluctuations cannot be due to mechanical irregularities;

if they were so then the numbers of different organisms should increase and decrease together as the speed of winding slackened or increased. This does not occur. Except for mechanical failure the silk roll is wound on at a speed in direct relation to the rate of passage of the recorder through the water.

In addition to such considerations, however, a direct test of the patchiness of oceanic plankton was made by the use of a consecutive series of tow-nets. The method, first used in investigating the patchiness of the macroplankton at South Georgia, has already been described by Hardy and Gunther (1935, p. 255). Two nets, exactly the same in every particular, are towed alternately at the same speed and each for the same length of time. As one net comes in on the port quarter the other net is lowered away from the starboard quarter and *vice versa*; whilst one net is fishing the other is washed down, the sample collected and the net made ready for use again. At South Georgia coarse-mesh nets had been used for the macroplankton; in the present series finer-mesh nets of 70 cm. opening were used (the N 70 nets of the South Georgia survey); the front part of the net is of 40 meshes to the inch and the hind section of 74 meshes to the inch (see Hardy and Gunther, 1935, p. 17). Each net was towed for 10 min. at a depth of 0–5 m. at a speed of 2 knots. Fifty-seven consecutive hauls were made, covering a distance of 19 miles. The experiment was made from the R.R.S. 'William Scoresby' in the South Atlantic Ocean half-way between Gough Island and Cape Town (St. WS 133) on the night of June 14–15, 1927. This series comes between records 31 and 32 (see Fig. 1). Fig. 18 shows the volumes of the plankton samples obtained after the salps, which are shown separately, had been removed. The samples were composed almost entirely of Copepoda, young Euphausiacea, *Limacina*, and Chaetognatha; the comparative proportions of these different groups were roughly estimated as percentages of the volumes and filled in in the histograms. Marked fluctuations are seen not only in the total volumes, but also in each of the four groups of organisms, comparable with the type of fluctuations revealed by the recorder. A typical patch of salps[1] is well illustrated.

There is then no doubt as to the patchy nature of the oceanic plankton. As pointed out in the description of the recorder methods (Hardy, 1936, p. 495) the fluctuations observed on the records are really less marked than those actually in the sea because there is an overlap in the sampling; each section samples also part of the water sampled by the sections on each side of it. The plotted curves of fluctuations produced are thus in reality smoothed curves.

As far as the investigations have gone, fluctuations appear to be as marked in the tropical waters (records 34 and 35) as in the Antarctic Zone (records 11, 12, 13, 25, 26 and 27).

It may now be convenient to bring together the evidence regarding the fluctuations in the different plankton groups afforded by the thirty-five records described.

Globigerina is only represented in any numbers on records 23–26 and Radiolaria on records 23 and 24. As far as the records go they suggest regions of greater abundance rather widely spaced from each other.

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[1] Kindly identified by Professor W. Garstang as *Salpa fusiformis*, Cuv.

The Diphyidae are also only poorly represented. A small concentration is noticed in record 4, but a fairly even distribution in record 35.

The Chaetognatha (records 4, 5, 18, 20, 27, 28, 29, 34 and 35) show on the whole a continuous distribution with short-spaced fluctuations.

The Ostracoda are only represented by one well-defined patch in record 8.

The Copepoda are represented in sufficient numbers to chart in all records except 7 and 24. Marked fluctuations are the rule, and as will be discussed presently there is a suggestion that these fluctuations may follow in a certain rhythm, the pattern of which varies on different occasions. Vertical migration undoubtedly plays an important part in the variations in the numbers observed, but on top of these migrational variations actual fluctuations are evident.

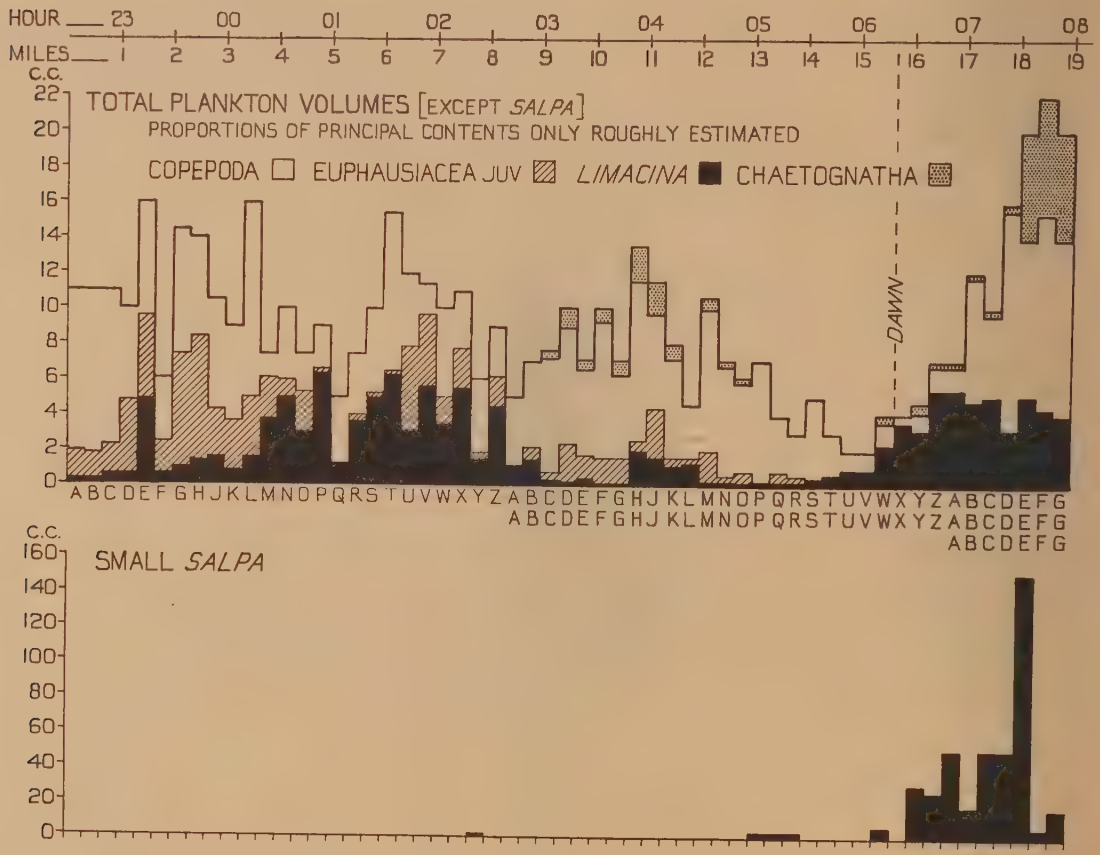

Fig. 18. Variations in the plankton, measured as volumes but omitting *Salpa* (*S. fusiformis*) shown separately, taken by a series of consecutive surface tow-net hauls each towed for $\frac{1}{3}$ of a mile at a speed of 2 knots. The relative volumetric proportions of the predominant plankton forms: Copepoda, Euphausiacea juv., *Limacina* and Chaetognatha are shown for each haul. For further explanation see text.

Of the amphipods, young *Parathemisto* are alone taken in sufficient numbers to consider and on only two records 25 and 26. Here the fluctuations may be due to vertical migration, but the remarkable patchiness in distribution of *P. gaudichaudi* has been well demonstrated at South Georgia (Hardy and Gunther, 1936, p. 260).

Young Euphausiacea occur in all records but 1, 2, 4, 23, 24 and 27. Whilst also affected by vertical migration they show marked fluctuations with as a rule the peaks close together. Here, too, there are indications of a certain rhythm in the fluctuations. The apparent restricted zones of adult Euphausiacean distribution in records 5 and 6 are most likely explained by vertical migration, but not so the dense patch of *Euphausia longirostris* in record 22 in daylight.

The pteropod *Limacina* (records 7–11, 27, 28, 30–33) shows marked fluctuations and particularly a tendency to occur in isolated patches. The young gastropods *Ianthina* fluctuate in record 3.

Salps show remarkable fluctuations in record 7 and a tendency to occur in isolated patches in records 2 and 33, and also in the continuous net series (St. WS 133, Fig. 18). The numbers of *Doliolum* (record 3) are too small for the fluctuations to be significant.

On reviewing the records as a whole it is difficult not to be impressed by the suggestion of an apparent rhythm in the fluctuations; a rhythm which is not constant for different groups, but one which appears to have a definite pattern on different occasions. A few examples will illustrate what is meant. In Fig. 17 the young Euphausiacea fluctuate with fairly closely spaced peaks in record 34, whereas the peaks are far apart in record 35. In records 8 and 9 (Fig. 8) the copepod fluctuations follow one another in a pattern of alternating low and high peaks. Records 18–22 (Fig. 11) suggest a rhythm of widely spaced major fluctuations in the copepods, and in record 31 (Fig. 15) a rhythm of lesser fluctuations combined with vertical migration. Even the small numbers of copepods in record 2 (Fig. 3) show wave-like fluctuations. See also the euphausian larvae in Fig. 9. It is perhaps easy for one's imagination to exaggerate sporadic fluctuations into such rhythmic patterns, and for the moment they must remain as tentative suggestions. If such rhythmic fluctuations should be established by further observations as a common phenomenon of plankton distribution, then it seems likely that they must be caused by some dynamic principles involving vertical migration and water movements such as have been recently outlined by the author (Hardy and Gunther, 1935, pp. 343–56). If they were due to the action of the sea alone one would expect all organisms in the same area to fluctuate to the same "rhythm"; we see, however, different organisms fluctuating on the same records with their peaks at different intervals apart, suggesting that these differences are due to differences in the behaviour (vertical movements?) of the animals in relation to the water.

Whether there are in reality such rhythms or not it is evident from the foregoing records that the plankton is seldom uniformly distributed even in the most open ocean regions. That part of Haeckel's classical attack upon the theories of Hensen and the Kiel planktologists based on his conception of the unequal distribution of the oceanic plankton appears to have been fully justified.

SUMMARY

Thirty-five records taken with the Continuous Plankton Recorder in oceanic regions are described and these demonstrate marked fluctuations in the distribution of the main planktonic groups of animals.

These spatial fluctuations appear to be no less marked in the tropics than in the Antarctic Zone.

The types of distribution shown by different groups are discussed.

The existence of a rhythm in the distributional fluctuations is tentatively suggested, a rhythm which varies on different occasions.

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